S. HRG. 98-1064

EAST-WEST COOPERATION IN OUTER SPACE

HEARING

BEFORE THE

COMMITTEE ON FOREIGN RELATIONS
UNITED STATES SENATE

NINETY-EIGHTH CONGRESS

SECOND SESSION

ON

S.J. Res. 236

A JOINT RESOLUTION RELATING TO COOPERATIVE EAST-WEST VENTURES IN SPACE AS AN ALTERNATIVE TO A SPACE ARMS RACE

SEPTEMBER 13, 1984

Printed for the use of the Committee on Foreign Relations

U.S. GOVERNMENT PRINTING OFFICE
39-395 O WASHINGTON : 1984

S381-40

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EAST-WEST COOPERATION IN OUTER SPACE

THURSDAY, SEPTEMBER 13, 1984

UNITED STATES SENATE,
COMMITTEE ON FOREIGN RELATIONS,
Washington, DC.

The committee met, pursuant to notice, at 10:01 a.m., in room SD-419, Dirksen Senate Office Building, Hon. Charles McC. Mathias, Jr., presiding.

Present: Senators Mathias, Pell, and Biden.

Also present: Senator Matsunaga.

Senator MATHIAS. The committee will come to order.

Let me first make an announcement. There had been an expectation that the committee would convene a business meeting at 11 o'clock, at which time we would vote on the Genocide Treaty. However, an agreement has not yet been reached, and the expectation is that it will not be reached by 11 o'clock this morning.

Therefore, discussions will continue in the hope of reaching an agreement on the treaty, and as soon as it is reached, a meeting of the committee will be called.

I am advised that if no agreement is reached by Wednesday, September 19, that a business meeting of the committee will be held at 10 o'clock with a vote on the Genocide Treaty to occur no later than 11 o'clock.

This hearing today is to discuss Senate Joint Resolution 236, introduced by the distinguished Senator from Hawaii, Mr. Matsunaga, for himself, for the Senator from Rhode Island, Mr. Pell, and for me.

The resolution calls upon the President to renew the 1972-77 Outer Space Cooperation Agreement between the United States and the Soviet Union and to initiate talks with all interested governments to explore opportunities for cooperative East-West ventures in space as an alternative to the space arms race.

A great deal of attention has been paid in the last year to the further militarization of outer space. This committee has spent many hours debating the pros and cons of antisatellite [ASAT] weapons testing, the President's strategic defense initiative [SDI], and the prospects for fruitful arms control agreements affecting space.

But I am afraid that until today the committee has not spent any time examining the pros and cons of cooperative, nonmilitary East-West ventures in space. And we are hoping today to begin a process—I doubt that we will complete it in a single session, but to begin a process that deserves at least as much attention as the debate over the space arms race.

In June, the President held a ceremony at the White House at which he told a number of American scientists meeting to discuss the future of United States-Soviet exchanges that, in his words, "civilized people everywhere have a stake in keeping contacts, communication, and creativity as broad, deep and free as possible."

Now, it seems to me that cooperative ventures in outer space can contribute to the President's goal. The 1975 Apollo-Soyuz program is evidence of that. Apollo-Soyuz marked the high point, both literally and figuratively, of successful United States-Soviet cooperation in outer space. I think it remains a symbol of superpower collaboration instead of confrontation to peaceloving people throughout the world.

[Text of S.J. Res. 236 follows:]

II

98TH CONGRESS
2D SESSION

S. J. RES. 236

Relating to cooperative East-West ventures in space as an alternative to a space arms race.

IN THE SENATE OF THE UNITED STATES

FEBRUARY 9 (legislative day, FEBRUARY 6), 1984

Mr. MATSUNAGA (for himself, Mr. PELL, and Mr. MATHIAS) introduced the following joint resolution; which was read twice and referred to the Committee on Foreign Relations

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JOINT RESOLUTION

Relating to cooperative East-West ventures in space as an alternative to a space arms race.

Whereas the United States and the Soviet Union are on a course leading toward an arms race in space which is in the interest of no one;

Whereas the prospect of an arms race in space between the United States and the Soviet Union has aroused worldwide concern expressed publicly by the governments of many countries, including most of the allies of the United States, such as Australia, Canada, France, the Federal Republic of Germany, India, Japan, and the United Kingdom of Great Britain;

Whereas an arms race in space would open the door to a range of new weapons systems that would seriously threaten

global stability, undermine the prospects for successful arms control agreements, and create pressures for new defense expenditures unprecedented in scope even for these times;

Whereas the 1972–1975 Apollo-Soyuz project involving the United States and the Soviet Union and culminating with a joint docking in space was a significant success, thus proving the practicability of a joint space effort;

Whereas, shortly after the completion of the Apollo-Soyuz project, and intended as a followup to it, the United States and the Soviet Union signed a formal agreement to examine the feasibility of a Shuttle-Salyut program and an international space platform program, but that initiative was allowed to lapse;

Whereas the United States signed a five-year space cooperation agreement with the Soviet Union in 1972, renewed it in 1977, then chose not to renew it in 1982, despite numerous scientific benefits accruing to the United States as a result of joint activities initiated under that agreement;

Whereas the opportunities offered by space for prodigious achievements in virtually every field of human endeavor, leading ultimately to the colonization of space in the cause of advancing human civilization, would probably be lost irretrievably were space to be made into yet another East-West battleground; and

Whereas allowing space to become an arena of conflict without first exerting every effort to make it into an arena of cooperation would amount to an abdication of governmental responsibility that would never be forgotten: Now, therefore, be it

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the President should—

(1) renew the 1972–1977 agreement between the United States and the Soviet Union on space cooperation for peaceful purposes;

(2) initiate talks with the Government of the Soviet Union, and with other governments interested in space activities, to explore the opportunities for cooperative East-West ventures in space as an alternative to an arms race in space, including cooperative ventures in such areas as space medicine and space biology, space rescue, planetary science, manned and unmanned space exploration; and

(3) submit to the Congress at the earliest possible date, but not later than October 1, 1984, a report detailing the steps taken in carrying out paragraphs (1) and (2).

○

Senator MATHIAS. Let me now defer to Senator Pell for his statement.

Senator PELL. Thank you very much, Mr. Chairman.

Mr. Chairman, I am proud to be an original sponsor of Senate Joint Resolution 236, the subject of today's hearing. We are fortunate to have such a distinguished expert panel before the committee to give us informed judgments on the potential benefits of peaceful cooperation in space.

Fortunately, space—the last frontier—is, for now, a nuclear weapons-free zone. Unfortunately, the administration so far has given no indication it appreciates the importance of keeping space free of weapons.

There is no negotiation to control space-based or space-directed weapons in prospect, and the emphasis clearly is upon preparing to fight space wars. Undoubtedly, the Soviets are prepared to do the same.

Before it is too late, we must ask whether our own self-interest is space in which cataclysmic war is a looming threat, or is space in which an exemplary peace prevails.

If we are wise enough to seek the latter situation, we will do all that we can to bring about space arms control and to foster peaceful cooperation for our benefit and that of all nations.

Our relations with the Soviets have deteriorated alarmingly in recent years. As various ties, such as the agreement on space, have been terminated, the incentives for the Soviets to be restrained and responsible in their international dealings have diminished.

Isolating the Soviet Union will not make it better. Dealing with the Soviet Union in the full awareness that it is an adversary can help get both sides off the present collision course.

I have been a close observer of the Soviet Union for years. I led a Senate delegation there a year ago and came back convinced, more than ever, that, while maintaining strong defense, we must find ways to deal with the Soviets to our mutual interest.

We must find productive ways to deal with them if we are to reduce tensions and spare mankind the terrible threat of nuclear war.

Cooperation in space offers an excellent and unique opportunity. Working together, the two sides can engage in various scientific ventures which will provide concrete benefits to our societies and to other nations.

Working on a people-to-people basis, we can discover and build upon those peaceful scientific aspirations we share. Each side has much to offer. We must be willing to choose cooperation.

In closing, I would like to express my appreciation for the excellent paper the Office of Technology has provided on a symposium held at our request to explore the potential benefits of space cooperation. Dr. Bernard Burke, who chaired the symposium, and Ms. Nancy Naismith, who is overseeing this project, deserve our special commendation.

Thank you, Mr. Chairman.

Senator MATHIAS. Senator Matsunaga, would you like to make a statement?

Senator MATSUNAGA. Yes, I would. Thank you very much, Mr. Chairman, and Senator Pell.

I am deeply honored to be granted the privilege of serving with you today as a temporary member of the Foreign Relations Committee.

Mr. Chairman, I have a prepared statement which I would like to submit for the record, and which I would like to summarize as follows.

Senator MATHIAS. Your full statement will appear in the record.

Senator MATSUNAGA. Thank you.

In a letter to me endorsing Senate Joint Resolution 236, former astronaut "Deke" Slayton wrote of the 1975 Apollo-Soyuz linkup in space in which he participated, and here I quote:

> In my opinion, the major thing the Soviets could have learned to their everlasting benefit is how to conduct major technical programs efficiently through use of free lateral and vertical communications among all participants.
>
> This would also have been to our major benefit, because it is called democracy. Unfortunately, we have not opted to learn these lessons yet, but we should not give up hope.

Indeed, the chief difference between the United States and the Soviet Union is that ours is an open society, guided by democratic values and institutions, whereas theirs is a closed society dominated by a secretive and repressive police state apparatus.

To the extent that they open up, they become more like us. To the extent that we close down, we become more like them. Nothing could be more in our interest in every decent respect than to develop long-term policies that protect our openness while encouraging the Soviets toward greater openness, rather than the other way around, as now seems to be the case.

To that end, I propose, with the cosponsorship of Senator Mathias and Senator Pell, a policy of aggressive cooperation that would set strict standards for joint activity in space. We would press those standards hard in the teeth of Soviet repression, constantly seeking new and expanded activities that push the Soviets toward greater openness.

Mr. Chairman, I have elaborated upon a policy of aggressive cooperation in an article which appeared in last Sunday's Washington Post, and which I ask unanimous consent be included in the hearing record at this point.

Senator PELL [presiding]. Without objection.

[The article referred to follows:]

[From the Washington Post, Sept. 9, 1984]

WITH MOSCOW TO MARS

(By Spark Matsunaga)

The case of Andrei Sakharov and Yelena Bonner dramatizes the central question of our nuclear age:

How are two nations which hold the fate of the world in their hands to relate to one another when their ruling value systems stand at diametrically opposing poles?

During the past 15 years, two sharply contrasting U.S. policies have emerged. The Nixon-Ford-Kissinger administration practiced what Richard Nixon aptly called "hardheaded détente." Its tools were trade and other forms of cooperation, combined with discreet pressure applied as part of a process of continuing negotiation.

Although it produced considerable flexibility for lateral movement, "hardheaded détente" could not last as an American policy for the same reason it held so much appeal to the Soviet leadership: it lacked moral content. Its goal was world order in

the classic European sense. It was suspicious of internal forces for change that threatened established ruling elites—in the Soviet Union, Chile, wherever.

Jimmy Carter remedied that defect with a vengeance. He placed human rights at the center of his policy toward the Soviet Union and repeatedly "punished" (a word he favored) the Soviets for morally unacceptable behavior. The tools employed by Carter to administer punishment were, to a considerable extent, the various components of the web of interdependencies developed by Nixon-Ford-Kissinger.

Under Ronald Reagan, that moralistic emphasis reached an apex with the description of the Soviet Union as the "focus of evil," as relations between the superpowers deteriorated and the arms race accelerated.

Which approach is preferable? Each, in my view, contains serious deficiencies. A policy in tune with American values and interests requires both moral concern and tactical flexibility, both calculation and compassion.

One way to serve American values and interests at once would be to establish cooperative activity as an overriding national objective to be pursued with calculated sophistication and moral determination. This policy would replace the prevailing vacillation between no contacts and an uncritical pursuit of contacts, which the Soviets exploit by limiting their participation to party hacks. It would set strict standards for cooperation and push them hard.

A policy of aggressive cooperation would recognize that the chief enemy is less world communist ideology, which takes many evolving forms (China, Hungary, Yugoslavia), than it is the repressive Soviet police state, which is compulsively hostile to any evolution at all, communist or otherwise.

Instead of responding to repugnant Soviet behavior by cutting off contacts as "punishment" (which actually makes work easier for the police state apparatus), we would keep up the pressure, constantly pushing for new and expanded contacts of substance in the teeth of Soviet repression. Our principal target would be the emerging scientific and technical elite, the most sophisticated and cosmopolitan segment of Soviet society, who enjoy the highest status, upon whom the totalitarian power structure depends for running the system.

In pursuing that target, we could expect much more support than now from our European and Japanese allies, who already favor increased cooperation and greater flexibility in dealing with the Soviets.

Would such a policy legitimize Soviet policies of repression toward Sakharov, Bonner and others? On the contrary, it would constitute the strongest and most effective rejection of those policies. The Soviet police apparatus thrives on isolation. Why assist its efforts? Under present conditions, whenever they want to tighten the screws at home, they need only create an incident. We have handed them flexibility at our expense. In an important sense, American policy has made itself hostage to the KGB.

A policy of aggressive cooperation might best be launched with a proposal to do something big with the Soviets. It must be a long-term undertaking that locks them into an expanding program of joint activity. Soviet policy makers must find it sufficiently appealing to stay in, although it places their reactionary system of internal contracts increasingly at risk.

One promising possiblilty is an international manned mission to Mars in the 21st century. It could be put forward as an alternative to competing Star Wars space weapons systems, which would otherwise be developed in the same time frame.

Unlike Star Wars, it requires no technology breakthroughs and thus would be far less costly. Unlike Star Wars, which would polarize scientific inquiry on the greater frontier of space, it would mobilize the world's best scientists and engineers in a common endeavor on behalf of all humanity. Unlike Star Wars, it would mandate ever greater openness across an expanding front, to the thriving benefit of democratic values and interests. And unlike Star Wars, our allies would welcome it with relief and excitement, for it would be a response to the greater problem of our time that is wholly in tune with the best in the American character.

Joint activity on a grand scale would respond to the deepest aspirations of Andrei Sakharov. In the late 1960s and early 1970s, Sakharov sought to nudge the Soviet Union in precisely that direction. Then the police apparatus moved in and re-established the "us" versus "them" condition upon which it thrives.

"Any action increasing the division of mankind, any preaching of the incompatibility of world ideologies and nations is madness and a crime," Sakharov wrote. With such utterances, his descent from official favor began, until, alone and isolated, he could retain his integrity only by lashing back at his captors.

But we should not confuse his entrapped response with the deep univeral spirit that moved him to seek the intellectual freedom which must inevitably ensue from expanded communication and joint activity on an international scale. We have it in

our power to resurrect that noble spirit. All we need is the will and determination—and the leadership.

Senator MATSUNAGA. I would only reiterate today that if we are to initiate a long-term policy of that nature, we need to entice the Soviets into something big. I propose a program consisting of space missions of gradually increasing complexity, linked to a moratorium on space weapons testing, and building toward an international manned mission to Mars in the 21st century.

We hear a lot of talk these days about creative visions of the future. Permit me now to offer this open vision of exploration, of discovery on an epic scale, a truly American vision in my view, as an alternative to a currently faddish video game, a vision best suited for application in amusement arcades.

Any suggestion that our greatest scientific minds should be mobilized in a national effort dedicated to finding newer and jazzy outlets for infantile fantasies, rationalized in a thousand ways, is an insult to American intelligence and imagination.

Even as fantasy, the so-called strategic defense initiative is a second-rate production, a perversion of the uniquely human capacity to create great new transcendent forms that unify. That is what creative vision is all about.

So, I look forward to hearing today's expert witnesses with great anticipation. I think we have our work cut out for us. We need a new American vision of the future that is truly worthy of our ideals and our heritage, and we need to convert our new vision to reality by fashioning policies that set this Nation on a new ascendent course.

It should be a course that future generations, endless future generations can pursue with excitement and wonder, guided by a unifying vision invoked by their forebears in the 20th century, even as they stood on the brink.

Perhaps today's hearing, which I believe is the first of its kind conducted by a committee of the U.S. Congress, will help set us under way.

I thank you, Mr. Chairman, for permitting me to join on this important occasion.

[Senator Matsunaga's prepared statement follows:]

PREPARED STATEMENT OF HON. SPARK M. MATSUNAGA

Senator Mathias, Senator Pell, I am deeply honored to join the distinguished members of the Senate Foreign Relations Committee in examining a policy alternative that holds unusual promise for our endangered species. Let me first state that I am acutely aware of the pitfalls associated with trying to cooperate with the Kremlin, beginning with the common belief that its occupants rarely can be trusted, and moving on to their almost pathological distrust of others. And yet, more and more, I am even less attracted to the alternatives. Not the least of my concerns is the impact on American values and institutions of policies deriving from the easy assumption that U.S.-Soviet differences are irreconcilable and that we must therefore anticipate, if not welcome it sometimes seems, a condition of tense hostility enduring into the indefinite future. Aside from the probability, which increases with time, that the two determined antagonists will one day annihilate each other, if not all life on this planet, I am concerned about the effect on American society of an open-ended, overriding commitment to policies required by an adversary relationship of such size, scope and intensity.

Dr. George Keyworth, the President's Science Adviser, told this Committee a few months ago that space weapons technologies were, and here I quote, "a natural by-product of our civilian industries and universities." He was referring to the increas-

ing dependence of military systems on the common advanced technological base of modern society. But Dr. Keyworth drew back from the ominous implications of the condition he observed, though they are already being felt amongst us. New research controls, new export controls, new restrictions on publication and travel, all commonly associated with brief intermittent periods of war, and now being institutionalized in peacetime. A 100-year trillion dollar high technology Star Wars program that aspires to send the arms race into orbit, literally, can only fortify and accelerate that insidious process, with all it portends for American values and institutions, for our economic efficiency, our productivity, our capacity for innovation, all of which are products of an atmosphere that fosters openness.

Indeed, the chief difference between the United States and the Soviet Union is that ours is an open society, guided by democratic values and institutions, whereas theirs is a closed society, dominated by a secretive and repressive policy state apparatus. To the extent that they open up, they become more like us, to the extent that we close down, we become more like them. Nothing could be more in our interest, in every decent respect, than to develop long-term policies that protect our openness while encouraging the Soviets toward greater openness, rather than the other way around as now appears to be the case.

In a letter to me endorsing Senate Joint Resolution 236, former astronaut Donald "Deke" Slayton wrote of the 1975 Apollo-Soyuz linkup in space, in which he participated, and here I quote: "In my opinion, the major thing the Soviets could have learned, to their everlasting benefit, is how to conduct major technical programs efficiently through use of free lateral and vertical communications among all participants. This would also have been to our major benefit because it is called 'democracy.' Unfortunately, they have not opted to purloin these lessons yet, but we should not give up hope."

I could not agree more. Although modest in its juridical requirements, S.J. Res. 236, which I introduced with the cosponsorship of Senators Mathias and Pell, would open up a whole new policy context for relating to the Soviets over the long-term. It would make possible what I call a policy of aggressive cooperation. This policy would replace prevailing vacillation between no contacts and an uncritical pursuit of contacts that the Soviets consistently exploit by limiting their participation to party hacks. It would set strict standards for cooperation and press them hard, in the teeth of Soviet repression. We would constantly seek new and expanded joint activities which would push the Soviets toward greater openness in their dealings with the outside world, and thus, of necessity, with one another. Mr. Chairman, I have elaborated upon a policy of aggressive cooperation, including how it relates to the heroic struggle of Dr. Andrei Sakharov, in an article which appeared in last Sunday's Washington Post, and which I ask unanimous consent to include in the hearing record.

I would only reiterate today that if we are to initiate a longterm policy that accomplishes the objectives I have mentioned, we need to entice the Soviets into something big. My suggestion is a program consisting of space missions of gradually increasing complexity, linked to a moratorium on space weapons testing, and building toward an international manned mission to Mars in the 21st century. While pursuing this new path of exploration and discovery, the Americans and Soviets might even rediscover their common humanity.

We hear a lot of talk these days about creative visions of the future. Permit me now to offer this open vision of exploration and discovery on an epic scale, a truly American vision in my view, as an alternative to a currently faddish video game vision best suited for application in amusement arcades. Any suggestion that our greatest scientific minds should be mobilized in a national effort dedicated to finding newer and jazzier outlets for infantile fantasies, rationalized in a thousand ways, is an insult to American intelligence and imagination. Is that how America's leadership educates its youth? Our dawning space age doesn't need to be guided by another hopeless quest for yet another polarizing weapons system that breeds pathological suspicion and secrecy and places democratic values and institutions increasingly at risk. Dare we call this backward vision progress? Even as fantasy, the so-called strategic defense initiative is a second-rate production, a perversion of the uniquely human capacity to create great new transcendent forms that unify. That's what creative vision is all about.

So I look forward to hearing today's witnesses with great anticipation. I think we have our work cut out for us. We need a new American vision of the future that is truly worthy of our ideals and our heritage. And we need to convert our new vision to reality by fashioning policies that set this nation on a new ascendant course. It should be a course that future generations, endless future generations, can pursue with excitement and wonder, guided by a unifying vision invoked by their forebears

in the 20th century, even as they stood on the brink. Perhaps today's hearing, which I believe is the first of its kind conducted by a committee of the United States Congress, will help set us underway. I thank you, Mr. Chairman, for permitting me to join you on this important occasion.

Senator PELL. Thank you very much, Senator Matsunaga, for your statement, and more particularly for having introduced this resolution in the beginning.

I think we should get started with our panel at this point. We will hear all our witnesses, and then we will ask our questions of them. Our first witness today will be Dr. Carl Sagan, who is David Duncan professor of astronomy and space sciences, and director of the Laboratory for Planetary Studies at Cornell University.

Dr. Sagan, welcome.

STATEMENT OF CARL SAGAN, DAVID DUNCAN PROFESSOR OF ASTRONOMY AND SPACE SCIENCES AND DIRECTOR, LABORATORY FOR PLANETARY STUDIES, CORNELL UNIVERSITY, ITHACA, NY

Mr. SAGAN. Thank you, Senator Pell.

I would like to begin by stating that my remarks represent myself only, and not necessarily any organization I may be affiliated with.

The bill proposed by Senator Matsunaga is an extremely important and useful proposal, and I believe it is proper to consider major cooperative efforts in space and star wars as alternatives.

Certainly major new and peaceful ventures in space could proceed in parallel with the early stages of star wars, but for economic reasons, additional differences, questions of secrecy, and the like, the two activities—a massive military space program or a massive civilian one—tend to exclude one another.

I would like first to state briefly why I think that the administration's strategic defense initiative is so dangerous and pernicious. It is very much like the debate on MIRVing written large. MIRVing was proposed some 15 or 20 years ago as a proposed response to an imagined effective Soviet antiballistic missile threat.

The idea was that first you would add decoys and penetration aids to the U.S. attacking warheads so that you would overwhelm the defenses of the Soviet Union. But then it was realized that the decoys and penetration aids would be detectable as different from warheads, because they had a different mass to area ratio. The response was to make decoys with the same mass-to-area ratio as the nuclear weapons. Then someone must have said, if we are going to do that, why don't we make them all nuclear weapons?

It was immediately pointed out that this is a tremendously destabilizing step, because now there is a premium and incentive to destroy the MIRVed missile on the ground before it is launched, where with one warhead you can detroy 10 or so of the opposition's.

This objection went by the boards. It was a massive technological momentum that was built up, and it was impossible to stop.

Today, the United States and the Soviet Union have added enormously to their strategic arsenals by MIRVing. Both sides recognize fully that both nations are less secure now than before MIRV-

ing. Even former advocates of MIRVing such as former Secretary of State Kissinger now publicly regret their earlier support.

So, with great expense. MIRVing has significantly increased the instability of the global confrontation between the United States and the Soviet Union. It has made the world a less safe place.

I think if we take that MIRVing example as an historical reminder, and multiply it by a factor of 10 or 100, we have some idea of what is very likely going to happen with the strategic defense initiative if we are so unwise as to implement it.

There are at least five or six major problems with it. First, even sympathetic critics believe that the system will be porous, that it will permit a certain fraction of attacking warheads to come in, and because the destructive power of nuclear weapons is so great, even a few percent of attacking missiles—after all, a Soviet strategic attack might involve 10,000 warheads—would utterly destroy the United States.

Second, a very reasonable response by the Soviet Union to U.S. implementation of the strategic defense initiative is simply to increase the number of attacking warheads and overwhelm the defenses. It is cheaper to increase the number of warheads than to build the strategic defense initiative.

The advantage is on the side of the attacker if there is an arms race of this sort. What is more, since no one knows how well the system would work, military prudence would compel the Soviets to assume that the U.S. system is better than it is, and therefore to build still more, a safety factor of additional warheads, the net result of which could be that we would be considerably worse off than we are right now.

Third, there is the question of cost. It now looks very much, and this is based in part on the Department of Defense's own estimates, by Under Secretary of Defense DeLauer, for example, that a full-blown deployed strategic defense initiative would cost something like $1 trillion, a $1,000 billion.

That seems to me to be of some relevance in a time of justifiable concern about the budget.

Then there is the clear implication that a number of U.S. strategic alliances, especially NATO, can become unraveled over this issue because it looks very much like a move toward Fortress America, with the United States intending to survive a nuclear war and NATO or Japan hopelessly vulnerable to a nuclear war.

It also unilaterally abrogates a number of treaties that the United States has solemnly ratified.

Finally, the deployment of an effective strategic defense initiative, if that were possible, is the equivalent of the strategic disarmament of the Soviet Union by the United States. It would, in the words of the President—if it were to work, which is highly unlikely—render Soviet ballistic missiles "impotent and obsolete."

It is unlikely that the Soviet Union would find this an agreeable prospect, and if a competent such system were about to be deployed, there would be a much greater incentive for a preemptive attack by the Soviet Union.

So, this is one of many ways in which the building of the system at enormous expense is likely to significantly enhance the likelihood of nuclear war on Earth.

Now, let me try to make the bridge between this proposed star wars system and the crux of Senator Matsunaga's bill, which is to envision major cooperative peaceful scientific space ventures between the United States and the Soviet Union.

I find it extremely interesting that—while there is enormous debate within the scientific community on the strategic defense initiative—very large numbers of scientists with substantial experience in the Department of Defense, group leaders at the Manhattan project, and the like, a wide spectrum of scientists have publicly voiced very serious reservations about the strategic defense initiative.

And yet, it is hard to find a single scientist or executive of an aerospace corporation who has voiced any such reservations. I think this absence of public dissent on the side of the aerospace industry is an important reminder of the institutional inertia of our economic system, and the likelihood that were this trillion-dollar program to begin to be implemented, it would become almost impossible to stop.

There are jobs on the line. There are corporate profits on the line. There are promotions, both civilian and military, on the line. And once this thing gets going, it is almost impossible to stop, just as was the case for MIRV's—even though in both cases it is perfectly easy to see how extremely serious and dangerous the disabilities of this system are.

Senator MATHIAS [presiding]. Dr. Sagan, you mentioned the word "stopping."

Mr. SAGAN. Yes, slowing down, deceleration.

Senator MATHIAS. Unfortunately, because of the large number of witnesses that we have today, we have asked the witnesses to limit themselves to something like 7 to 10 minutes.

Mr. SAGAN. I will conclude, Senator. Thank you.

Therefore, the question, it seems to me, is what is a beneficial, peaceful, forwardlooking activity which can usefully engage the individuals and abilities of the aerospace industry in something other than star wars. I believe that a major cooperative venture in space between the United States and the Soviet Union could provide that function, could give a dramatic new feeling of hope that these two nations might be engaged in something for the benefit of the human species, instead of jointly engineering the present trap that the species finds itself in.

There are in the solar system a range of worlds, of the most enormous significance and interest, worlds crying out for exploration. It is well within our capability, both technical and financial, to muster missions to them.

One mission I would like in particular to commend to your attention. It seems to combine major scientific goals, practical applications back on Earth—by examining another planet, we better understand our own—and a sense of optimism about the future. It is a set of expeditions to the planet Mars, culminating in missions with human crews.

A study supported by the Planetary Society has recently been performed which suggests that, for less than the current equivalent cost of the Apollo program, a major such mission to Mars could be mustered.

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The year 1992 happens to be both the 500th anniversary of the discovery of America by Christopher Columbus and the 75th anniversary of the Bolshevik Revolution. It is conceivable that an activity designed to begin in that year might find some symbolic and practical political favor in both the United States and the Soviet Union.

Thank you for your attention.

Senator MATHIAS. Thank you very much.

Mr. Friedman.

STATEMENT OF LOUIS FRIEDMAN, EXECUTIVE DIRECTOR, THE PLANETARY SOCIETY, PASADENA, CA

Mr. FRIEDMAN. Thank you, Mr. Chairman.

Mr. Chairman, Senators, intense nationalistic rivalries characterized the early years of the space age, culminating when an American first walked on the Moon. Although the rivalry was intense, the United States and the Soviet Union conducted a race in space with peaceful and exploratory objectives.

The competition began in 1957 with the launch of Sputnik, an attempt by the Soviets to show their superiority through a scientific project. The American response was characterized by the 1958 Space Act, which stated that "Activities in space should be devoted to peaceful purposes for the benefit of all mankind" and "in cooperation with other nations and groups of nations."

Despite its roots in nationalistic rivalry, the legacy of the Apollo era was a magnificent and positive achievement obtained by exploring another world with benefits for all mankind.

That exploratory momentum carried on into the 1970's with the world acclaimed Viking exploration of Mars, Voyager explorations of Jupiter and Saturn, and Venera explorations of Venus.

More recently, there has begun an escalating trend toward the use of space for active weapons systems and hence toward making space a potentially more aggressive environment.

With the research and development phase of the proposed strategic defense initiative estimated to be a larger program than all of NASA, including the proposed space station, by the end of this decade, we have a striking reversal in the priorities of U.S. space activities.

This inevitably projects a different image to the rest of the world than did our earlier activities. Sending an American astronaut to the Moon and American robots to Mars and to the extraordinary systems of Jupiter and Saturn projects the image of a self-confident, outward-looking country.

In contrast, massive new technology developments for weapons systems makes space a mirror reflecting, correctly or not, the image of a less secure, more inward-looking people. It is important that we balance this changing perspective of ourselves by encouraging global participation in peaceful space projects.

Cooperation serves the U.S. national interest. It enables communication among scientists and technicians engaged in similar research, helps in the planning of experiments and observations, advances science and technology, demonstrates capability and leadership, speeds accomplishments of major projects, and enhances op-

portunities to find areas and means of reducing tensions or misunderstandings.

Nations cooperate on space missions for four primary reasons: Intellectual stimulation—the interaction of scientists and engineers from different countries; broadens knowledge; and permits interchange of ideas, for example, this has been true among scientists working on the comparative studies of Earth, Venus, and Mars with data from the Soviet and American planetary probes.

Technical advantages.—With cooperative partners, missions can be optimized to take advantage of particular expertise from different nations, this is now being done on the U.S. Galileo project to Jupiter and the Soviet VEGA project to Venus and Halley's Comet.

Economic.—With nations sharing the cost of missions, lower individual costs for projects are possible in any given nation, that is, from any given budget;

And fourth, national policy.—National policy vis-a-vis international interests may be served by nations cooperating on benign projects of high visibility, technology, and science.

International cooperation is a sign of self-confidence, and we should therefore make equal the commitment for global participation in a peaceful program as we do the development of defensive and other military systems, out of fear.

Because U.S.-U.S.S.R. cooperation on exploratory projects serves the U.S. self-interest mentioned earlier, and because the carrot and stick approach of punishing and rewarding the Soviets for their behavior has never worked, we should not apply the doctrine of linkage and withhold cooperation because of tensions, nor should we invoke new Soviet aggressiveness as a reason to avoid cooperation.

The situation in the 1980's is not much different from the 1960's and the 1970's when United States-Soviet tensions were centered around such places as Cuba, East Germany, and Southeast Asia. The difference now is in the United States, and in our own self-perception. It is our perception of ourselves that is now inhibiting our willingness to cooperate.

An oft cited reason in opposition to cooperative United States-Soviet programs is the fear of technology transfer, of giving away the store, but the United States is an open society, and the Soviet Union a closed one, and we have much to gain by adding windows and doors between the two nations.

Space biology, life support technology, automatic rendevous and docking, and planetary lander systems are but four areas where we can gain knowledge from the Soviet Union. A recent Congressional Research Service overview of United States-Soviet Union cooperation stated that no instances of technology transfer through cooperative space science programs could be found.

International cooperation is now an inherent part of space exploration. Of the 12 projects exploring the solar system in the 1980's, by the United States, Europe, Japan, and the Soviet Union, 9 already include significant international cooperation. As missions get more complex and expensive, international cooperation will only increase.

The United States is no longer dominant in space exploration. For example, U.S. scientists will only participate in the close-up encounters of Halley's Comet as guests of other nations. Both Europe

and Japan's first planetary missions will be fly-throughs of Halley's Comet.

The Soviet Union's Venus-Halley mission is a highly ambitious undertaking involving new technology and a new international program for the Soviets. Similar new and exciting missions are being planned by the U.S.S.R. for the late 1980's and 1990's.

Although the United States will not be dominant in space exploration, we will be an active participant, and it is encouraging to see some new programs being proposed for the 1980's and 1990's. No one nation can be or even should be dominant. The scope of exploration is too large, and the benefits for all too great.

Instead of dominating, we can lead in bringing nations together to create a whole enterprise of space exploration that can be larger than the sum of its parts, the individual space programs of nations.

For example, we could be at the forefront of the greatest scientific adventure imaginable when humans once again take part in exploring the solar system, most likely, as has already been noted, at Mars.

It would be hard to imagine that the United States would not be playing such a principal role in exploration. Recently there has been new interest in major exploratory initiatives into the solar system, initiatives that will determine the possibilities for human evolution beyond the earth.

A cooperative U.S.-U.S.S.R. program in planetary exploration that might lead to human flight to Mars would be of enormous significance to the cause of global security and international stability. It would be a tremendous step in the exploration of space.

The Planetary Society recently commissioned a private industry study of this and other manned mission possibilities. A manned mission to Mars would be achievable sooner, and with a cost less than 10 percent of that associated with implementing the proposed strategic defense initative.

It is hard to imagine this creative enterprise being undertaken by the two nations while simultaneously they conduct other space activities, adding to mutual distrust and fear. But because of the magnitude and character of such an ambitious and extensive program, and because of the cost, it is not likely that it would be done or even justified unilaterally, but only in cooperation with other space-faring nations.

We should encourage bilateral discussions and bilateral cooperation, which are now discouraged by our Government between NASA and their Soviet counterparts as well as multilateral and other international programs.

With more than 125,000 members in every State and on every continent, the Planetary Society is the largest space interest group in the world. To support international cooperation, the Society is establishing membership worldwide, arranging international meetings among space scientists for promoting ideas and plans, distributing its magazine, and enabling global communications among the many individuals and organizations sharing our objectives.

Recently we held a significant meeting in Graz, Austria, of leading American and Soviet scientists involved in the two countries' space exploration programs. Soviet academicians, leaders from the U.S.-based Science Board, and NASA committees, and key experi-

menters on planetary missions got together for a wide-ranging agenda concerning possibilities for United States-Soviet cooperation in planetary exploration.

Dr. Sagan chaired this meeting, and I might mention some of the principal findings from it. Planetary science has benefitted greatly in the past from American-Soviet cooperation on Venus and Mars exploration programs. I believe we will hear more testimony on this from another witness.

Opportunities for similar benefits exist for the future on more exploration activities, at Mars, Venus, satellites of the planets, comets, and asteroids. A reasonable and logical program of cooperation and planetary science can be constructed beginning with data exchanges and scientist to scientist interactions leading to complementary planning, shared experiments, and even joint missions.

Third, the absence of government sanction, and indeed the presence of official discouragement has reduced opportunity, lessened contact, and hindered communication. Official ties and support are needed. Renewal of the space treaty, of the Treaty on Space Cooperation would help.

The Senate Commerce, Science, and Transportation Committee of the 97th Congress concluded, "space cooperation is a fixed principle in contemporary international life has intrinsic value of its own. Rooted in the scientific-technological revolution, it deals with issues generated by this revolution, providing the means for composing differences and satisfying vital interests in an area common to the concerns of all nations.

"In an interdependent world, cooperation is a tool serving the interests of all. It has a future, whatever the state of Soviet-American relations, but a future whose full potentialities can only be realized in a climate of reasonable peace and harmony."

Therefore, the Planetary Society supports a renewal of the 1977 Treaty on Space Cooperation. We believe it would serve U.S. self-interest, enhance global relations, and lead to great and lasting enterprises, enterprises that may well be our legacy for all humanity.

[Mr. Friedman's prepared statement follows:]

PREPARED STATEMENT OF LOUIS FRIEDMAN

Mr. Chairman, this statement represents some preliminary thoughts that The Planetary Society is developing as part of a report on "Opportunities for United States and Soviet Union Cooperation on Planetary Exploration." There are two general reasons for support of international cooperation between the United States and the Soviet Union in space exploration. The first has already been addressed: it is good for science and advances the progress of exploration. I will focus more on the second reason: Namely, it is good for the United States' self-interest as a nation and as part of global civilization.

Intense, nationalistic rivalry characterized the early years of the space age and culmination when an American first walked on the Moon. Although the rivalry was intense, the United States and the Soviet Union conducted a race in space with peaceful and exploratory objectives. The competition began in 1957 with the launch of Sputnik, an attempt by the Soviets to show their superiority through a scientific project. The American response was characterized in the 1958 Aeronautics and Space Act which stated that: "Activities in space should be devoted to peaceful purposes for the benefit of all mankind," and "in cooperation with other nations and groups of nations." Despite its roots in nationalistic rivalry, the legacy of the Apollo era was a magnificent and positive achievement, obtained by exploring another world with benefits proclaimed "for all mankind."

The exploratory momentum of the Apollo era carried into the 1970's with the world-acclaimed Viking exploration of Mars, Voyager explorations of Jupiter and

Saturn, and Venera exploration of Venus. Since the end of the Apollo program, new United States space efforts in general have been focused on utilitarian activities such as the development of the space transportation system, commercialization of space communications, and continued evolution of passive military systems. More recently, there has begun an escalating trend toward the use of space for active weapon systems and, hence, towards making space a potentially more aggresive environment. With the research and development phase of the proposed Strategic Defense Initiative estimated to be a larger program than all of NASA—including the proposed space station—by the end of this decade, we have a striking reversal in the priorities of U.S. space activities. This inevitably projects a different image to the rest of the world than did our earlier activities. Sending an American astronaut to the Moon and American robots to Mars and to the extraordinary systems of Jupiter and Saturn, projects the image of a self-confident, outward-looking country. In contrast, massive new technology developments for weapon systems makes space a mirror, reflecting, correctly or not, the image of a less secure, more inward-looking people.

It is important that we balance this changing perspective of ourselves by encouraging global cooperation on peaceful space projects. Cooperation serves the U.S. national interests. It enables communication among scientists and technicians engaged in similar research, helps in the planning of experiments and observations, advances science and technology, demonstrates capability and leadership, speeds accomplishments of major projects, and enhances opportunities to find areas and means of reducing tensions or misunderstandings. Nations cooperate on space missions for four primary reasons:

Intellectual stimulation.—The interaction of scientists and engineers from different countries broadens knowledge and permits interchange of ideas. For example, this has been true among scientists working on comparative studies on Earth, Venus, and Mars with data from the Soviet Union and American planetary programs.

Technical advantages.—With cooperative partners, missions can be optimized to take advantage of particular expertise from different nations. This is now being done on the U.S. Galileo project to Jupiter and the Soviet VEGA project to Venus and Halley's Comet.

Economic.—With nations sharing the cost of missions, lower individual costs for projects are possible in any given nation, that is, from any given budget. The decision to do the mission may be easier. Another way of looking at this is that more can be done on a given mission than would be possible from a single national investment.

National policy.—National policy vis-a-vis international interests may be served by nations cooperating on benign projects of high visibility, technology, and science.

International cooperation is a sign of self-confidence and we should therefore make equal the commitment for global participation in a peaceful program, as we do for the development of defensive and other military systems out of fear. Because United States-U.S.S.R. cooperation on exploratory projects serves the U.S. self-interests mentioned earlier, and because the carrot and stick approach of punishing and rewarding the Soviets for their behavior has never worked, we should not apply the doctrine of "linkage" and withhold cooperation because of tensions. Nor should we invoke "new" Soviet aggressiveness as a reason to avoid cooperation. The situation in the 1980's is not much different from the 1960's and 1970's when United States-Soviet tensions were centered around such places as Cuba, East Germany, and Southeast Asia. The difference now is in the United States and in our own self-perception. It is our perception of ourselves that is now inhibiting our willingness to cooperate.

An oft-cited reason in opposition to cooperative United States-Soviet programs is the fear of technology transfer—of "giving away" the store. But, the United States is an open society, the Soviet Union is a closed one, and we have much to gain by adding windows and doors between the two nations. Space biology, life-support technology, automatic rendezvous and docking, and planetary lander systems are but four areas where we can gain knowledge from the Soviet Union. A recent Congressional Research Service overview of United States-Soviet Union cooperation stated that no instances of technology transfer through cooperative space science programs could be found.

International cooperation is now an inherent part of space exploration. Of the twelve projects exploring the solar system in the 1980's from the United States, Europe, Japan, and the Soviet Union, nine include significant international cooperation. As missions get more complex and expensive, international cooperation will only increase. The United States is no longer dominant in space exploration. For

example, U.S. scientists will only participate in the close-up encounters of Halley's Comet as guests of other nations. Both Europe's and Japan's first planetary missions will be fly-throughs of Halley's Comet. The Soviet Union's Venus-Halley (VEGA) mission is a highly ambitious undertaking, involving new technology in a new international program for Soviets. Similar new and exciting missions are being planned by the U.S.S.R. for the late 1980's and 1990's.

Although the United States will not be dominant in space exploration, we will be an active participant and it is encouraging to see new programs being proposed for the 1980's and 1990's. No one nation can be, or even should be dominant—the scope of exploration is too large and the benefits for all too great. Instead of dominating, we can lead in bringing nations together to create a whole enterprise of space exploration that can be larger than the sum of its parts, the exploration programs of individual nations. For example, we could be at the forefront of the greatest scientific adventure imaginable when humans, once again, take part in exploring the solar system, most likely at Mars. It would be hard to imagine that the United States would not be playing a principal role in such exploration. Recently, there has been new interest in major exploratory initiatives into the solar system—initiatives that will determine the possibilities for human evolution beyond the Earth.

A cooperative United States-U.S.S.R. program in planetary exploration that might lead to human flight to Mars would be of enormous significance to the cause of global security and international stability. It would be a tremendous step in the exploration of space. The Planetary Society recently commissioned a private industry study of this and other manned mission possibilities. A manned mission to Mars would be achievable sooner and with a cost less than 10 percent of that associated with implementing the Administration's proposed Strategic Defense Initiative. It is hard to imagine this creative enterprise being undertaken by the two nations, while simultaneously they conduct other space activities adding to mutual distrust and fear. But because of the magnitude and character of such an ambitious and extensive program, and because of the cost, it is likely that it would not be done or even justified unilaterally, but only in cooperation with other space-faring nations. While this program could be undertaken chauvinistically or nationalistically, history suggests such reasons, and any gains realized this way, are temporary at best. Spain's, Portugal's, and Holland's dominance were short-lived. For this reason, we are better advised to lead in the process of international cooperation, rather than being dragged in through the back doors or as intermediaries, as is now the case. We should encourage bilateral discussions and bilateral cooperation, which are now discouraged by our government, between NASA and their Soviet counterparts, as well as multilateral and other international programs.

With more than 125,000 members in every state and on every continent, The Planetary Society is the largest space interest group in the world. To support international cooperation, the Society is establishing membership worldwide, arranging international meetings among space scientists for promoting ideas and plans, distributing its magazine, and enabling global communications among the many individuals and organizations sharing our objectives. Currently, we have membership branches in Canada, Australia, Japan, the Netherlands, Hungary, China, and the Soviet Union, and members in scores of other countries.

Recently, we held a significant meeting in Graz, Austria of leading American and Soviet scientists involved in the two countries' space exploration programs. Soviet academicians, leaders from the U.S. Space Science Board and NASA committees, and key experimenters on planetary missions got together for a wide ranging agenda concerning possibilities for United States-Soviet cooperation in planetary exploration. Dr. Sagan chaired the meeting and is describing some of the specifics about it in his statement, but I might mention the principal findings:

1. Planetary science has benefitted greatly in the past from American-Soviet cooperation on Venus and Mars exploration programs, and opportunities for similar benefits exist for the future on more exploration activities—at Mars, Venus, satellites of the planets, comets, and asteroids.

2. A reasonable and logical program of cooperation in planetary science can be constructed beginning with data exchanges and scientist-to-scientist interaction, leading to complementary planning, shared experiments, and even joint missions.

3. The absence of government sanction and, indeed, the presence of official discouragement, has reduced opportunity, lessened contact, and hindered communication. Official ties and support are needed; renewal of the treaty on space cooperation would help.

The Senate Commerce, Science, and Transportation Committee of the 97th Congress concluded: "Space cooperation, as a fixed principle in contemporary international life, has intrinsic value of its own. Rooted in the scientific-technological revo-

lution, it deals with issues generated by this revolution, providing the means for composing differences and satisfying vital interests in an area common to the concerns of all nations. In an interdependent world, cooperation is a tool serving the interests of all. It has a future, whatever the state of Soviet-American relations, but a future whose full potentialities can only be realized in a climate of reasonable peace and harmony."

Therefore, The Planetary Society supports a renewal of the 1977 treaty on space cooperation. We believe it would serve U.S. self-interest, enhance global relations, and lead to great and lasting enterprises—enterprises that may well be our legacy for all humanity.

Senator MATHIAS. Thank you very much.

Dr. Burke.

STATEMENT OF BERNARD F. BURKE, WILLIAM A.M. BURDEN PROFESSOR OF ASTROPHYSICS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MA

Mr. BURKE. Mr. Chairman, members of the committee, I am reporting as chairman of a workshop on possible future United States-Soviet space cooperation held by the Office of Technology Assessment on May 8, 1984.

The group represented virtually all aspects of space science and all had had experience in working with Soviet scientists or with data resulting from Soviet space science research.

The participants were charged to evaluate the scientific exchanges that took place under the former space science cooperation agreement, to assess current Soviet capability in space science, and to estimate the prospects, both positive and negative, of future cooperation in space science with the Soviets.

The principal areas of scientific cooperation under the former agreement were in space biology and medicine, studies of the Moon, the planets, and near Earth space, although discussions and exchanges of data occurred in astrophysics also.

The experience was generally a fruitful one. Three categories of exchange in the life sciences were especially valuable. First, flight experimental data regarding human response to space flight conditions.

Second, joint ground based simulations of the space flight conditions. And third, the opportunity for U.S. investigators to fly biological experiments on the Soviet Cosmos series biosatellites.

In planetary research, the strongest areas of cooperation were in lunar studies, the exploration of Venus, and solar terrestrial physics. The highlight of the life sciences work was probably the long duration flight data that the Soviets could provide from their extended manned space flight mission.

The Soviet data on bone loss and cardiovascular deconditioning were particularly valuable for the U.S. program. In the planetary program, the exchange of data was particularly useful in planning the expensive missions to Venus. Soviet scientists were able to use the U.S. data in planning their Venera landing cites and Venera data in turn are providing useful input to the United States-Venus radar mapper program.

In planetary science, as in the life sciences, the United States gained at least as much information as it provided. Progress was not without some difficulties, particularly in obtaining timely and accurate data, and in acquiring information on mission plans.

The panel agreed, however, that the situation had been improving substantially at the time when the agreement expired. At present, the general experience has been that the Soviets have continued to carry out all interchanges planned under the previous agreement.

On the other hand, it has not been easy to initiate new exchange programs, since the agreement has lapsed, although informal contacts still occur. There has been an encouraging note recently. The Soviets appear to be more willing to talk openly about their future mission plans as American scientists do.

This in the opinion of the panel is a favorable indication that mutually advantageous results could be expected in the future. Soviet scientists, however, stress that substantive cooperation depends upon the reestablishment of a formal exchange agreement.

The quality of Soviet space science has seen steady improvement over the years. Their earliest efforts in planetary exploration and astrophysics were not particularly impressive scientifically. Their capabilities in many areas of space science have increased greatly in recent years, however, and the evolution of their Venera program both with sophisticated landers and orbiting synthetic apperture radar have been impressive.

As their scientific and technical versatility have improved, their data have become more reliable. They now mount missions rapidly and confidently. At the same time, their program has become more open. The Soviets have been expanding their cooperative activities with other countries, presenting the possibility that the U.S.S.R. intends to become the world leader in international cooperative ventures in space.

The common U.S. view has been that in scientific exchanges, the Soviets can only gain and the United States only lose. The greatly increased Soviet capability in space science must be seen to change that state of affairs. In planetary research, the United States probably has more to gain than to lose from increased exchange and similar situations should develop in other areas.

The technology transfer question inevitably arises in discussing exchange agreements, and in most areas the issues are not clearcut. The data from space missions together with the description of instruments generally appear in open publications anyway, giving scientists of other countries much of the key technological information.

Delivery of instruments to the Soviets for integration into a spacecraft necessarily entails transfer of some information, but knowledge of the Soviet spacecraft interface requirements gives us some information in return. The risk of the instrument being dismantled for intelligence purposes is always present, but there is some question, given proper packaging of the instrument, as to whether the U.S.S.R. would learn much from the exercise.

The risk of embarrassment would probably not be worth the information gained. The workshop concluded that the technology transfer issue in space science is no longer as one-sided as it once was. In looking toward the future, the workshop participants agree that any cooperative agreement must be based on U.S. self-interest.

An exchange agreement must also be based on a strong U.S. program in order to provide incentives for Soviet cooperation. At the

same time, areas of complementarity should be sought. Cooperation must be founded on strength, and not regarded as a substitute for a vigorous national program.

The simplest levels of exchange, joint discussions, cooperative data analysis, and joint planning of separate missions were seen to be the easiest way to start. Experiments of one country mounted on spacecraft of the other were also viewed as practicable first steps, provided elementary precautions were taken concerning technology transfer. Joint coordination and tracking of separate spacecraft could be added to the program, maximizing scientific return, while minimizing the technology transfer concerns.

The concept of United States-Soviet coinvestigators could also be encouraged. Areas of scientific exchange that held promise for United States-Soviet cooperation were then explored in all fields. One could identify mutually advantageous areas of cooperation. The new program of global habitability, including a wide range of integrated environmental observations, offers numerous cooperative possibilities.

In the life sciences, research on life support systems, effects of long duration space flight, exobiology, and global biology were all candidate areas of cooperation. In the planetary field, joint Venus missions, coordinated Mars missions, or even a joint sample return mission, a cometary rendezvous and sample return, and outer planet exploration were identified as possibilities.

In astrophysics, several spacelab shuttle experiments could profitably use the longer time in orbit afforded by Salyut-class spacecraft, and joint radio interferometric observations of quasars could also be carried out using independent but coordinated spacecraft.

In solar-terrestrial physics, mission coordination and improved data exchange would yield mutually beneficial scientific results for both countries, both in magnetospheric studies and in studies of the solar wind.

The workshop participants discussed the question of whether it would be best to simply resume the former exchange agreement with modifications to reflect evolution of the United States and the Soviet programs since 1982 or to base an agreement on a more ambitious, highly visible project that could capture the world's imagination.

The consensus was that given the difficulties inherent in large-scale joint missions, it would be wise to begin with the simpler exchanges, working toward the possibility of more ambitious missions as a long-term goal. In this way, the scientific bonds could be strengthened gradually while moving toward a joint mission or missions in an evolutionary way.

In summary, we conclude the following. One, important scientific interchanges continue today, demonstrating the willingness of United States and Soviet scientists to cooperate, but these interactions are dwindling, and their future is uncertain.

Two, few initiatives are being taken. Leading Soviet scientists consistently express a strong wish to cooperate further, but little can be done without a formal framework for cooperation. There are cases where the lack of a bilateral agreement has been a clear impediment to space science exchanges.

Soviet capabilities are increasing rapidly in many areas of space science. Scientific and technical versatility has improved. Data are more reliable, and missions can be mounted more rapidly and with greater confidence.

Three, as Soviet capabilities have increased, their space program has become more open. The expansion of Soviet cooperative possibilities with other countries in space further improves their capabilities and presents the possibility that the U.S.S.R. will become a leader not only in space science but also in international cooperative ventures in space.

Four, increased Soviet mission capabilities mean that a fundamental change has occurred in the relative balance between the United States and Soviet space programs. In certain scientific areas, we may now have more to gain from the Soviets than they from us.

In the future, technology transfer could well become a more realistic Soviet concern as the direction of potential transfer becomes increasingly two-way.

Finally, I would like to add a few words about my own experiences in United States-Soviet scientific cooperation.

Senator MATHIAS. You are running on red, so it will have to be a very few words.

Mr. BURKE. Basically, I was one of a group who collaborated with the Soviets using radiotelescopes in the Soviet Union and the United States in a synchronized way, and the experience was, I would say, a genuinely two-way affair in which we certainly gained from the collaboration and they behaved as genuine colleagues in a very pleasant fashion.

I think if we do wish to have exchanges, we have to build on our strengths, not on artificial things, and encourage cooperation with the strong colleagues in the Soviet Union, so that you do develop a truly collegial relationship.

Thank you, Mr. Chairman.

[Mr. Burke's prepared statement follows:]

TESTIMONY BEFORE THE SENATE FOREIGN RELATIONS COMMITTEE

Bernard F. Burke

William A.M. Burden Professor of Astrophysics
Massachusetts Institute of Technology

September 13, 1984

Mr. Chairman and Members of the Committee:

I am reporting as Chairman of a workshop on "Possible Future U.S.-Soviet Space Cooperation," held by the Office of Technology Assessment on May 8, 1984. The group represented virtually all aspects of space science, and all had had experience in working with Soviet scientists or with data resulting from Soviet space science research. The participants were charged to evaluate the scientific exchanges that took place under the former space science cooperation agreement, to assess current Soviet capability in space science, and to estimate the prospects, both positive and negative, of future cooperation in space science with the Soviets.

The principal areas of scientific cooperation under the former agreement were in space biology and medicine, and in studies of the moon, the planets and near-earth space, although discussions and exchanges of data occurred in astrophysics also. The experience was generally a fruitful one. Three categories of exchange in the life sciences were especially valuable: firstly, flight experimental data regarding human response to spaceflight conditions; secondly, joint ground-based simulations of spaceflight conditions; and thirdly, the opportunity for U.S. investigators to fly biological experiments on the Soviet cosmos-series biosatellites. In planetary research, the strongest areas of cooperation were in lunar studies, the exploration of Venus, and solar-terrestrial physics.

The highlight of the life sciences work was probably the long-duration flight data that the Soviets could provide from their extended manned spaceflight missions. The Soviet data on bone loss (decalcification) and cardiovascular deconditioning were particularly valuable for the U.S. program.

In the planetary program, the exchange of data was particularly useful in planning the expensive missions to Venus. The Soviet scientists were able to use U.S. data in planning Venera landing sites, and Venera data in turn are providing useful input to the U.S. Venus Radar Mapper program. In planetary science, as in the life sciences, the U.S. gained at least as much information as it provided. Progress was not without some difficulties, particularly in obtaining timely and accurate data and in acquiring information on mission plans. The panel agreed, however, that the situation had been improving substantially at the time when the agreement expired.

At present, the general experience has been that the Soviets have continued to carry out all interchanges planned under the previous agreement. On the other hand, it has not been easy to initiate new exchange programs since the agreement lapsed, although informal contacts still occur. There has been an encouraging note recently: the Soviets appear to be more willing to talk openly about their future mission plans, as American scientists do. This, in the opinion of the panel, is a favorable indication that mutually advantageous results could be expected in the future. Soviet scientists, however, stress that substantive cooperation depends upon the reestablishment of a formal exchange agreement.

The quality of Soviet space science has seen steady improvement over the years. Their earliest efforts in planetary exploration and astrophysics were not particularly impressive scientifically. Their capabilities in many areas of space science have increased greatly in recent years, however, and the evolution of their Venera program, both with sophisticated landers and orbiting synthetic aperture radar, has been impressive. As their scientific and technical versatility have improved, their data have become more reliable. They now mount missions rapidly and confidently. At the same time, their program has become more open. The Soviets have been expanding their cooperative activities with other countries, presenting the possibility that the U.S.S.R. intends to become the world leader in international cooperative ventures in space.

The common U.S. view has been that in scientific exchanges the Soviets can only gain and the U.S. only lose. The greatly increased Soviet capability in space science must be seen to change that state of affairs. In planetary research, the U.S. probably has more to gain than to lose from increased exchange, and similar situations should develop in other areas.

The technology transfer question inevitably arises in discussing exchange agreements, and in most areas the issues are not clear-cut. The data from space missions, together with the description of instruments, generally appear in open publications anyway, giving scientists of other countries much of the key technological information. Delivery of instruments to the Soviets for integration into a spacecraft necessarily entails transfer of some information, but knowledge of the Soviet spacecraft interface requirements gives us some information in return. The risk of the instrument being dismantled for intelligence purposes is always present, but there is some question, given proper packaging of the instrument, as to whether the U.S.S.R. would learn much from the exercise. The risk of embarrassment would probably not be worth the information gained. The workshop concluded that the technology transfer issue in space science is no longer as one-sided as it once was.

In looking toward the future, the workshop participants agreed that any cooperative agreement must be based on U.S. self-interest. An exchange agreement must also be based on a strong U.S. program in order to provide incentives for Soviet cooperation. At the same time, areas of complementarity should be sought. Cooperation must be founded on strength, and not regarded as a substitute for a vigorous national program.

The simplest levels of exchange — joint discussions, cooperative data analysis, and joint planning of separate missions — were seen to be the easiest way to start. Experiments of one country mounted on spacecraft of the other were also viewed as practicable first steps, provided elementary precautions were taken concerning technology transfer. Joint coordination and tracking of separate spacecraft could be added to the program,

maximizing scientific return while minimizing technology transfer concerns. The concept of U.S.-Soviet co-investigators could also be encouraged.

Areas of scientific exchange that held promise for U.S.-Soviet cooperation were then explored. In all fields, one could identify mutually advantageous areas of cooperation. The new program of "global habitability," including a wide range of integrated environmental observations, offers numerous cooperative possibilities. In the life sciences, research on life support systems, effects of long-duration spaceflight, exobiology and global biology were all candidate areas of cooperation. In the planetary field, joint Venus missions, coordinated Mars missions or even a joint sample return mission, cometary rendezvous and sample return, and outer planet exploration were identified as possibilities. In astrophysics, several Spacelab (shuttle) experiments could profitably use the longer time in orbit afforded by Salyut-class spacecraft, and joint radio interferometric observations of quasars could also be carried out using independent but coordinated spacecraft. In solar-terrestrial physics, missions coordination and improved data exchange would yield mutually beneficial scientific results for both countries, both in magnetospheric studies and in studies of the solar wind.

The workshop participants discussed the question of whether it would be best to simply resume the former exchange agreement (with modifications to reflect evolution in the U.S. and Soviet programs since 1982) or to base an agreement on a more ambitious, highly visible project that could capture the world's imagination. The consensus was that, given the difficulties inherent in large-scale joint missions, it would be wise to begin with simpler exchanges, working toward the possibility of more ambitious missions as a long-term goal. In this way, the scientific bonds could be strengthened gradually, while moving toward a joint mission or missions in an evolutionary way.

In summary, we conclude the following:

1. Important scientific interchanges continue today, demonstrating the willingness of U.S. and Soviet scientists to cooperate. But these interactions are dwindling and their future is uncertain; few initiatives are being taken. Leading Soviet scientists consistently express a strong wish to cooperate further, but little can be done without a formal framework for cooperation. There are cases where the lack of a bilateral agreement has been a clear impediment to space science exchanges.

2. Soviet capabilities are increasing rapidly in many areas of space science. Scientific and technical versatility has improved; data are more reliable; and missions can be mounted more rapidly and with greater confidence.

3. As Soviet capabilities have increased, their space program has become more open. The expansion of Soviet cooperative activities with other countries in space further improves their capabilities, and presents the possibility that the U.S.S.R. will become a leader not only in space science but also in international cooperative ventures in space.

4. Increased Soviet mission capabilities mean that a fundamental change has occurred in the relative balance between the U.S. and Soviet space programs. In certain scientific areas, we may now have more to gain from the Soviets than they from us. In the future, technology transfer could well become a more realistic Soviet concern, as the direction of potential transfer becomes increasingly two-way.

* * * * * *

Finally, let me say a few words about my own experiences in U.S.-Soviet scientific cooperation. Since 1970 or so, a group of us in the U.S. have conducted experiments that made simultaneous use of radio telescopes in the U.S. and in the Crimea. In the course of this work, a lively interchange of ideas has developed between our Soviet colleagues and us, with a free exchange of ideas. We received at least as much as they did in the dialogue, and they were open in discussing their plans and programs. In the course of the work, the issue of technology transfer did arise from time to time. On the whole, their radio operations were conducted with their own equipment, some of it very good, some of it cruder but generally able to do the job. Two items of major equipment had to come from the U.S., and these were provided through normal channels with full U.S. Government approval. Both units were decade-old designs, freely available from U.S. and European suppliers, and I do not believe that Soviet technology derived any benefit from these instruments being at the Crimean radio telescope. The main lesson from our experience is that mutual benefit is clearly derived from such joint work, particularly in encouraging the exchange and development of new ideas. It is essential, in such exchanges, that we build on our own strength, and at the same time, that the Soviet scientists and programs be sufficiently strong to encourage the development of truly collegial relationships.

Senator MATHIAS. That was a useful addition to your statement. I am glad you took the extra time to make it. My own recollection is that in the science of biological warfare, even during the depths of the cold war, there was an exchange of scientific information that was mutually beneficial.

At the Fort Dietrick laboratories, scientists there would sometimes have difficulty in raising a certain strain, but would find that their Soviet counterparts were successful with that particular number, who were simply having trouble with some strains that were flourishing at Fort Dietrick.

In spite of the triple wire fences, police dogs, searchlights, and all the other security arrangements, a mutually beneficial scientific exchange took place, notwithstanding what else was happening in the world.

Dr. Masursky.

STATEMENT OF HAROLD MASURSKY, SENIOR SCIENTIST, U.S. GEOLOGICAL SURVEY, FLAGSTAFF, AZ

Mr. MASURSKY. I have read and heard the statements made by Drs. Friedman, Sagan, and Burke, and I will focus my statements on the particular experience in trying to work with the Soviets over the past 16 years.

I think that increased relations with the Soviets are useful——

Senator PELL. Would you please pull the microphone a little closer?

Mr. MASURSKY. Certainly. I favor the renewal of the agreement for three reasons. First, competition. Science is highly competitive, and Soviets are big players, and the more we are aware of what they are doing, the more it will encourage us to put our best efforts forward. It is like playing the Soviets in ice hockey. They are a considerable spur to doing better ourselves.

Second, coordination. That is, money is scarce. It is silly for us to both be planning missions to do the same things, so we should make our program and their program more effective by making sure that our programs are complementary.

And finally, possible cooperation. I realize how difficult this is to bring about. Let me go briefly through several involvements I have had with the Soviets to attempt to ameliorate the mythology that the exchange is always one way. That is, we are good. They are bad. They do not know anything. We can ignore them without any loss.

We had a close involvement with them even in the highly competitive lunar days. We had successful lunar orbiters and landers. They did also. We exchanged that data in a very successful fashion, and I will remind you that we brought back samples from the Moon bigger and better and earlier.

They would not accept a sample from us until they had brought one back. When they could exchange something, they gave us a sample, they received a sample. We do not have to watch them to ensure that the exchange is symmetrical. They refused to let it be any other way.

In the case of Mars, we had coordinate programs that were going on at the same time. We exchanged data. The data exchange was very free and very beneficial. They had numerous Mars failures. We had numerous Mars successes. Nevertheless, they were utterly frank in why the failures took place, gave us the engineering data that helped in the design of our Viking.

Even in this utter embarrassing situation, they were open and clearcut. They wanted an affirmance because on one of their missions they almost missed Mars, and they wanted to do better next time, and we were able to help in that case.

In the Venus thing, our successes were coordinate. They flew very early. We flew very early. We have had a contest to, let us say, match capabilities. They have focused on landers. We have focused on orbiters and atmospheric probes. But again, the exchange has been open and free. We have exchanged data.

We had two instruments on one of our spacecraft. They had two instruments. We got four data sets that did not agree at all, and we have been trying to understand what the difficulties are for mutual benefit.

Right now, they are flying Venus orbiters because we cancelled our VOIR, so in a year and a half they brought their spacecraft out of cold storage and flew it. I am not sure that we in fact could organize the science working group in that time, let alone launch a spacecraft.

You see, we have matched them in the enhancement of our bureaucracy. [General laughter.]

As to future exchanges, I would suggest that we can carry on in the present informal method, but I have heard statements from perhaps 10 different Soviet scientists and administrators that, yes, they can operate in an informal fashion. Their system is much more closely controlled than ours. An intergovernment agreement would enormously expedite the exchange of information.

It is true that as they have become more successful, they have become more open. They even have press conferences when their first mission data comes back, which is a new thing for them.

They are talking about future missions more openly. I would like to suggest the necessity for, if we really are going to do more than we are doing at the moment, that informal dinner parties are good, and we do exchange data. An intergovernment agreement would be much better, and we are more likely to do substantive things.

This is no substitute for a vigorous national program. We can only successfully deal with the Soviets if we have a full-fledged program ourselves. And then we can cooperate and enable us to do things that are beyond the capability of each side.

I have just come from a 2-day meeting at the Jet Propulsion Laboratory where the joint science working group between the National Aeronautics and Space Administration and the European Space Agency is planning a mission to Saturn and Titan in 1994. That will give you some idea of what the lead time is that is necessary for carrying out these very long and complex missions.

If we are going to do something with the Soviets in this century, we need to start soon, because both programs are set in their ways, and if we are going to affect them, we need to start very soon.

Second, we are reinvigorating our program, but we are looking forward to larger, more complex missions. Whenever we propose such a mission, the next subject is, who is going to help make that mission happen? How do we bring together the resources that will allow us to do these more complex missions? And we work closely with the Europeans. We are starting to work with the Japanese to try to make these things happen.

I suggest that other big league players are the Soviets. If we expect to fly big, complex missions, they are more likely to happen if we in fact engage with the Soviets. So, in summary, our exchanges in the past, we think they have tried very hard to match us. They have tried very hard to provide data that matches our data. They are very reluctant to sit down with us if they think they have nothing to contribute.

My anticipation is that they will try very hard if we do either a coordinate or a cooperative mission to at least match our contributions, so it seems to me only good can come of this kind of exchange. If we have an intergovernmental agreement, it will expedite this exchange, and perhaps allow us to do missions that are out of reach of our present resources.

It has already been mentioned that comet sample return, Mars sample return are enormously interesting missions. My guess is that it will be difficult for us to put on these missions by ourselves. I suggest that first we exchange data about Venus. We have agreed to exchange radar altimetry data to make a common map that both sides will use.

We are going to fly a Mars mission in 1990. They are going to fly one in 1988. We can exchange data about the calibration of our instruments, so we can add our two data sets together. They will be that much more effective.

If we want to do a big future Mars mission, almost surely it will require cooperation between ourselves, the Europeans, the Japanese, and the Soviet Union.

Thank you.

[Mr. Masursky's prepared statement follows:]

PREPARED STATEMENT OF HAROLD MASURSKY

I am appearing as a technical witness to describe my work with Soviet space scientists for the past 16 years. I was educated at Yale University and Northern Arizona University. I have been employed by the U.S. Geological Survey since 1946; I first worked in many states carrying out geologic investigations. I have worked on NASA space flight projects since 1962, when we began to make systematic geological maps of the Moon from earth-based telescopes.

Lunar and Planetary missions on which I've worked are as follows:

Inner Planets: Moon—Ranger, 1964; Lunar Orbiter, 1966; Surveyor, 1966; Apollo, 1969–70. Mars—Mariner 9, 1971; Viking, 1976. Venus—Pioneer Venus, 1978; Venus Radar Mapper 1988.

Outer Planets: Voyager, Jupiter, Saturn, Uranus, Neptune, 1979–1989. Galileo—(Jupiter Orbiter Probe), 1988.

I have worked closely with space scientists from the U.S.S.R. since the Tokyo COSPAR (Committee on Space Research) meeting in 1968 and more intensely since the Leningrad COSPAR meeting in 1970. I was a member of the Joint Planetary Data Exchange Group that met first at the Madrid COSPAR meeting in 1972, and has continued to meet intermittently; its last meeting was held in San Francisco in 1981.

We have worked closely with the Soviet scientists on lunar studies, trading photographs of the Moon taken by the U.S.S.R. Zond 8 and the USA Lunar Orbiter. We prepared maps for their Lunakhod (rover) missions. Later the USA and U.S.S.R. traded lunar samples returned by the Apollo and Luna missions.

Subsequently, we prepared maps of their proposed landing sites (Mars 4 and 5) on Mars. The entry data from their unsuccessful lander probes provided gave valuable data on parachute performance in the Mars atmosphere which was used for design and operations of the Viking landers. They also provided copies of photographic data and digital tapes taken by the Mars 4 and 5 orbiters.

We have prepared maps of landing sites on Venus for their Veneras 9, 10, 11, 12, 13, 14 and the future 17 and 18 missions. They have provided panoramic pictures and chemical data in advance of publication. They have also provided many pictures from their radar experiments on Veneras 15 and 16 that have been orbiting Venus. These pictures have helped us redesign and improve our radar experiment that will fly in 1988 to map Venus at higher resolution and with more complete coverage.

We will fly our Mars Geoscience Climatology Orbiter in 1990; they will fly their Phobos (a satellite of Mars) and Mars mission in 1988. We can cross-calibrate the similar instruments on the two orbiters and thus coordinate and amplify our observations. We did cross calibrations of this type, after the fact, for our Pioneer Venus mission and their Venera mission data. Past exchanges have been mutually beneficial and probably will continue to be so in the future.

Senator MATHIAS. Thank you very much, Dr. Masursky.

Before we begin questions, let me in the interest of fair play impose the same time limits on members of the committee that we imposed on the witnesses.

I am not sure when Senator Pell opened the panel that he directed that all written statements be included in the record in full, but if he did not do so, I will so direct, and if he did, I will do it again.

There has been some space cooperation, some contact with the Soviet Union since the lapse of the United States-Soviet space cooperation agreement. Now, you have testified this morning that one of the reasons to renew the agreement is to assure full cooperation

with the Soviet Union—that they currently as a formal matter do not feel free to go to the degree of cooperation that they would if the agreement were formally renewed.

What other advantages would you see to a renewal of the cooperation agreement? What would be the principal advantages if it were renewed?

Mr. MASURSKY. Do you want one at a time?

Senator MATHIAS. Anyone who is moved to speak.

Dr. Burke.

Mr. BURKE. I think in brief we see that with the agreement one could initiate large endeavors eventually that as Dr. Friedman said are larger than the sum of their parts. At this stage, we could talk to them, but it is not so easy getting something large underway.

Senator MATHIAS. What about physical exchanges of people? Is that happening today? Where do these exchanges take place? At meetings? At conventions? In correspondence? How does it work out in real life?

Mr. BURKE. Frequently at international meetings. The Soviets are not as free to travel as we are, but it seems that they are able to travel to Western Europe, and quite often we have informal meetings in Europe which are very colleagial in nature.

Senator MATHIAS. Were there specific scientific exchanges between the United States and the Soviet Union in which Soviet space scientists came to this country while the agreement was in force?

Mr. MASURSKY. [Nods affirmatively.]

Mr. SAGAN. [Nods affirmatively.]

Senator MATHIAS. I see both Dr. Masursky and Dr. Sagan saying yes.

Mr. MASURSKY. Yes, there was a meeting in 1981 to discuss these issues in San Francisco, and I think there were eight Soviets that came. Since then, they have only attended those meetings in very small numbers, which are, how shall I say it, meetings with much history of their attendance.

We are forbidden to organize a workshop, for example. We can invite an individual Soviet to come——

Senator MATHIAS. Now, you are talking about established fora of some sort or another?

Mr. MASURSKY. Yes.

Senator MATHIAS. International meetings?

Mr. MASURSKY. Yes.

Senator MATHIAS. But the bilateral exchanges are reduced, or nonexistent at the moment?

Mr. MASURSKY. I think anything more than individual participation by individual scientists on both sides are forbidden.

Senator MATHIAS. Dr. Sagan, did you want to add something on that?

Mr. SAGAN. I just wanted to add that there is, beyond these very clear scientific advantages to both sides, an additional element. With such cooperation in space, you buy at very low price a small increment of hope. Many people are despairing of the future of the world because of the nature of United States-Soviet Union relations.

What is a more fitting arena for the two nations to cooperate than in the exploration of space? Is it not reasonable for the exploration of other worlds to be carried out in the name of all the people of this small planet?

I think this kind of exploration provides a psychic energy, a psychological benefit that is extremely important, especially in the present political climate.

Senator MATHIAS. Dr. Masursky, I was interested in your description of the kind of opening up of Soviet attitudes toward information that they generate with respect to space activities. To what would you attribute that change?

Mr. MASURSKY. I think increasing confidence in their capability of doing things successfully. I think I have heard them say maybe 30 times that it is our custom to only talk about it after it has happened.

That is, they fire the rocket and see whether it works, and then they discuss it, and they say this is a philosophical matter that we do not believe in announcing what we are going to do. We talk about it after it has happened. They seem to be more willing.

And I think again they have watched us closely, and we published a document last year giving our program through the year 2000, and the Europeans last week put out a brochure about their plans to the year 2000, and the Soviets are now saying we have plans, too.

So, I think that, No. 1, they are more successful, and No. 2, they see the strong drift of the advantage of talking about a forward-looking program, and are gradually picking up that way of dealing with things.

Senator MATHIAS. Let me address a question to the panel at large. During the decade of the seventies a great deal of emphasis in the U.S. space program was on the space shuttle. I remember the painful process of the development of the shuttle and the many delays that we experienced in finally getting it off the ground.

What was the emphasis in space of the Soviet Union during the decade of the seventies?

Mr. FRIEDMAN. I think one emphasis was definitely in the long duration flights and Earth orbit construction for development of what I would have to term a space station capability. They have the capability now. They are essentially continuing that development of long life or long flight life systems, and they have also continued to develop in a number of other areas.

Dr. Masursky mentioned the capability of the planetary program which grew remarkably in the late 1970's and early 1980's with the Venera programs and the development of their ongoing VEGA mission. I think those are the two outstanding achievements that they have had.

Senator MATHIAS. Let me again ask the panel at large, first, what is the scientific significance of being able to stay in space for long periods of time? What kind of advantage does that provide? And second, on interplanetary exploration, how would you rate the Soviet effort as against our own?

Mr. SAGAN. There is some intrinsic interest in the long-term performance of human physiology under low gravity conditions. But it is also clearly a prerequisite for a certain category of future space

activities, permanently manned or womaned Earth satellites, and especially long voyages beyond the Earth-Moon system.

The Soviets have now had continuous human performance in near Earth orbital environments for something like 7 months.[1] That is comparable to what it takes to go from the Earth to Mars in certain interplanetary trajectories.

There was a recent report of the Office of Technology Assessment—not the excellent panel chaired by Dr. Burke, but another one—which indicated the opinion of that panel that human missions to Mars are a long-term Soviet goal.

Senator MATHIAS. And what you are saying is that this is demonstrated to be biologically possible?

Mr. SAGAN. The Soviets have now had humans in zero g for about as long as it would take to send humans from Earth to Mars.

Senator MATHIAS. Round-trip or one way?

Mr. SAGAN. One way. Then you land on Mars, and roust about at 38 percent of the gravity here. Then you gear up for the long voyage home. I should also say it is possible to devise spinning spacecraft, which in effect have artificial gravity, so that it is not absolutely essential to have long experience in zero g for such interplanetary flight. But it sure helps.

Senator MATHIAS. But there are serious scientific implications for this experiment.

Mr. SAGAN. Absolutely. Dr. Burke correctly said that the Soviets started off quite shaky in their exploration of the solar system, and have gotten consistently better. But even so, among their early achievements are the first spacecraft to land on the Moon, the first spacecraft to photograph the far side of the Moon, the first spacecraft to enter into the atmosphere of another planet. They did some quite good things very early, and the quality of the work has gotten much better.

Senator MATHIAS. I see Dr. Masursky wants to interject.

Mr. MASURSKY. Carl has nicely summarized what their intention is, and they have said many times that they will send men to Mars, and we cannot think of a reason for keeping men in space that long otherwise. That is a clear indication of their intention. In addition, they landed rovers on the Moon and ran them from the Earth. They landed spacecraft on the Moon, and returned an unmanned sample, so they are covering both bets.

Finally, I will give you a summary of the Soviet view of planetary exploration. They said, you are ahead on Mars, we are ahead on Venus.

Mr. SAGAN. Also, I might just mention a report in the August 27 issue of Aviation Week and Space Technology indicating an indication from Air Force reconnaissance satellites of preparations for launch of two extremely large Soviet booster rockets, one with comparable thrust to the Saturn 5 booster, which was central to the Apollo program—but which is no longer in the array of launch vehicles of the United States. It has been phased out.

Senator MATHIAS. Would you like to submit that article for the record?

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[1] The Soyuz/Salut 7 space mission by Levnid Kizim, Valimir Solovyov, and Oleg Atkov terminated on Oct. 2, 1984, after a recordbreaking 237 days in space.

Mr. SAGAN. I would be glad to.
[The material referred to follows:]

[From Aviation Week & Space Technology, Aug. 27, 1984]

SOVIETS READY NEW BOOSTERS AT TYURATAM

WASHINGTON.—U.S. Air Force imaging reconnaissance spacecraft are providing new data on the size and design of the Soviet Union's two large space boosters now undergoing advanced checkout on their launch pads at the Tyuratam launch site. The two new vehicles are comparable in size to the U.S. Saturn 5 and Saturn 1B vehicles used during the Apollo program.

As part of an effort to keep pace with the latest Soviet space developments, the National Aeronautics and Space Administration's Langley Research Center has completed a series of secret wind tunnel tests on a U.S.-built model of the Soviet small winged spaceplane.

The high velocity tests at the Hampton, Va., facility are designed to aid understanding of how this vehicle flies during reentry and better understand the level of Soviet technology involved.

Additional U.S. assessments of a different Soviet program—development of a heavy space shuttle—indicate the Soviets plan to use liquid oxygen/liquid hydrogen propellants in the strap-on boosters for the shuttle, as in the two large new expendable boosters already on the launch pad.

The heavy Soviet shuttle has not yet been mated on the launch pad. It differs from the U.S. shuttle in that its main engine group will be discarded after each launch since the engines are mounted on the vehicle's external tank. Intelligence reports indicate that the Soviets may take their hydrogen fuel technology a step farther in these new vehicles by employing "slush hydrogen" that has a denser, snow-like consistency.

If employed, this would enable more hydrogen fuel to be placed in vehicle's fuel tanks than could be placed in the same volume using liquid hydrogen.

Whether slush hydrogen will be employed early in the heavy shuttle and heavy expendable flight programs or is only in preliminary development remains a question. Also unknown is the overall status of oxygen/hydrogen engine development in the Soviet Union.

The launch timing and success of the large new Soviet space vehicles will depend upon maturity of the oxygen/hydrogen systems that will be used. The largest of the two new Soviet vehicles is comparable in size to the 7.5-million-lb.-thrust U.S. Saturn 5 that propelled nine Apollo missions to the Moon and launched the Skylab space station. The Saturn 5-class booster on the launch pad at Tyuratam consists of a central two-stage rocket core with four large strap-on boosters. The core stands about 200 ft. tall and the overall vehicle is painted white.

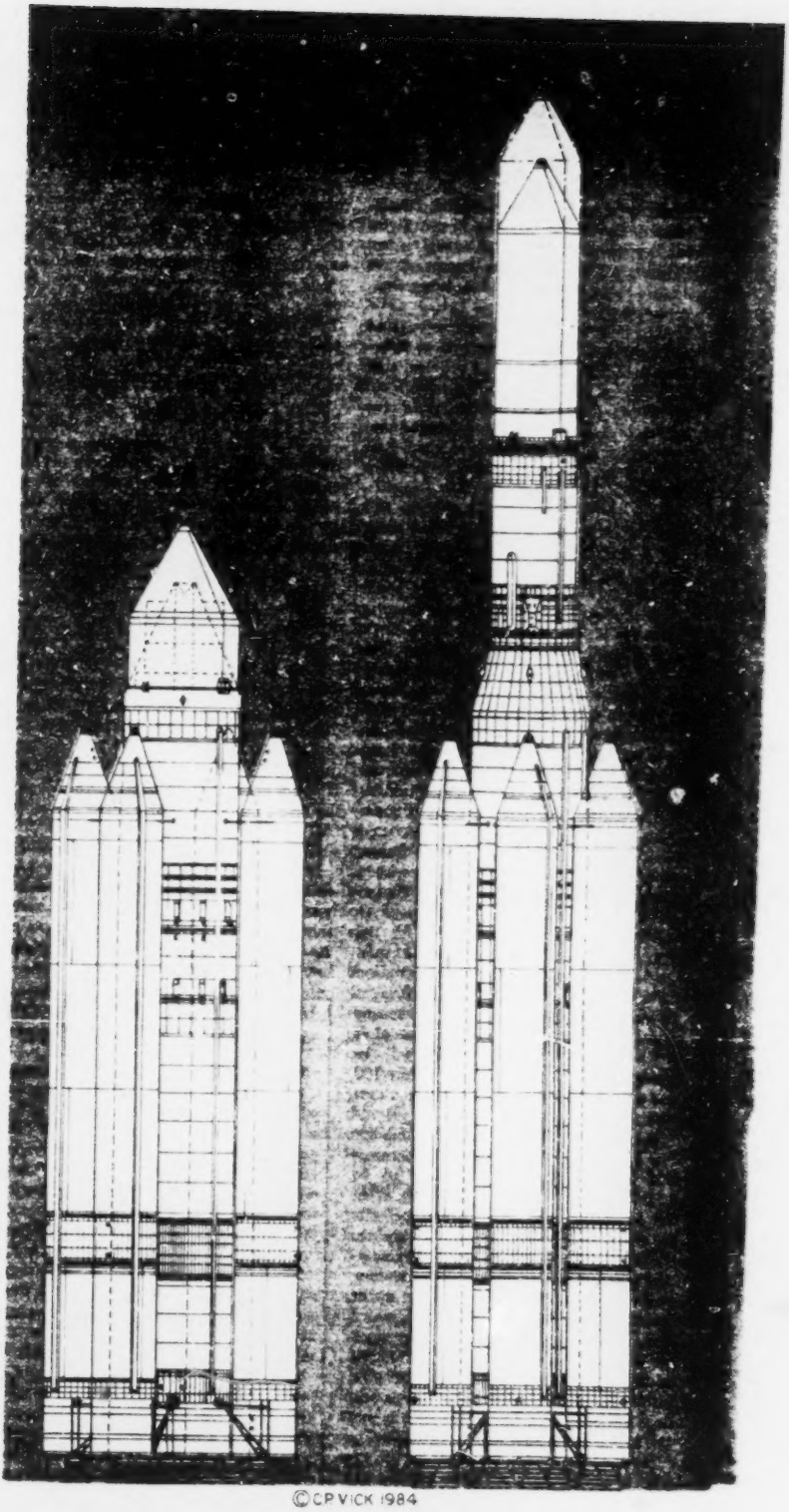
The strap-on boosters rise about 165 ft. on the side of the central core, an unusually high percentage of vehicle length compared with other Soviet and U.S. vehicles with strap-on boosters.

The first stage of the core is expected to use liquid oxygen/kerosene propellants. The strap-on boosters and second stage are expected to use liquid oxygen/hydrogen propulsion.

This two-stage/four strap-on configured vehicle on the pad is considered a development flight configuration.

OPERATIONAL MISSIONS

For operational missions, the booster is expected to utilize six strap-on boosters and a third stage with payload that will push vehicle height to 330 ft. This height is almost identical to the U.S. Saturn 5/Skylab configuration. The Soviet vehicle is flanked on one side by an umbilical/service tower with a large hammerhead crane on top.



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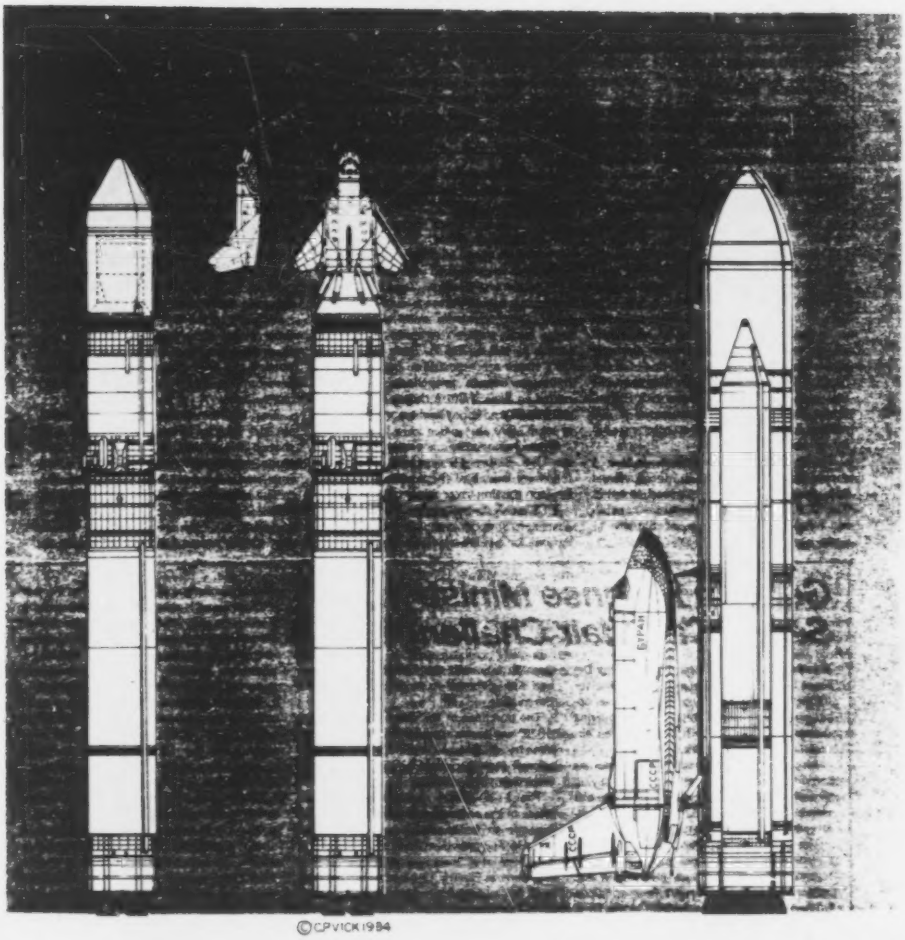

New Soviet heavy lift booster on the launch pad at Tyuratam is depicted in drawings of two configurations (preceding page, far left). It is a two-stage vehicle with four liquid-propulsion strap-on boosters. The vehicle is painted white and stands about 200 ft. tall. Once operational, the vehicle is expected to be a 330-ft. three-stage vehicle with six strap-on boosters as illustrated (second from left). The vehicle will have a liftoff thrust of 8 to 9 million lb. and a payload-to-orbit capability of about 330,000 lb. The strap-on boosters are shown on only one side of the vehicle. New Soviet medium-lift booster also on a launch pad at Tyuratam is a two-stage single stack vehicle as shown on this page, left. This vehicle is about 220 ft. tall and has a payload-to-orbit capability of about 33,000 lb. One possible mission for this new Saturn-1B-class vehicle would be to launch the Soviets small manned wing spaceplane under development and shown this page, second from left, mated to the new Soviet launcher. Overall length of this combination is about 230 ft. The heavy Soviet space shuttle, illustrated at far right in a side view, shows the lack of main engines on the orbiter vehicle. The main engines are located on the vehicle's external tank and within the large strap-on propulsion system mounted on each side of the tank. The tank is about 223 ft. tall.

The primary payload planned for the vehicle is Soviet space station elements and Soviet space-based laser weapons platforms (AW&ST June 16, 1980, p. 26). The core vehicle is about 26 ft. wide and with each strap-on booster being an additional 13 ft. wide, has a total base diameter across the core and two strap-ons of about 52 ft. This is about 19 ft. wider than the first stage of the U.S. Saturn 5. Liftoff thrust for the vehicle is estimated at 8–9 million lb. with a payload to orbit capability of about 330,000 lb.

This compares with a U.S. Saturn 5 capability of 7.5-million-lb. liftoff thrust and about a 280,000-lb. payload to orbit. The U.S. abandoned the Saturn 5 capability following the launch of Skylab 11 years ago.

Another large new Soviet vehicle also is undergoing advanced checkout prior to its first flight.

This Soviet booster is comparable in size to the U.S. Saturn 1B that launched several unmanned Apollo tests to Earth orbit and five manned Apollo missions.

The Saturn-1B-class vehicle on the launch pad at Tyuratam is also painted white and consists of a 20-ft.-wide, two-stage stack with no strap-on boosters. It stands as tall as 220 ft. Both of the vehicle's stages are expected to be powered by hydrogen/oxygen propellants. It is estimated to have a liftoff thrust of about 1.3 million lb. and a payload-to-orbit capability of 33,000 lb.

These parameters are nearly identical to the U.S. Saturn 1B capability abandoned following launch of the Apollo-Soyuz Test Project mission over nine years ago.

U.S. analysts believe the vehicle and its Tyuratam support complex are being configured for a relatively high annual launch rate using this booster. The vehicle is expected to be used for a variety of payloads. Analysts believe one likely use for the Saturn 1B class booster will be to launch a full-scale manned version of a small Soviet winged spaceplane.

Since 1982 the Soviets have flown at least two subscale spaceplane tests. One made a landing in the Indian Ocean; the other in the Black Sea (AW&ST Mar. 12, p. 111).

Langley high velocity wind tunnel testing of the Soviet spaceplane design shows that it flies its reentry imbedded within its own bow shock wave.

"We do that testing routinely; we are always looking at what they are doing to see if the technology would be useful in our own case," the NASA Administrator James M. Beggs said about the Soviet spaceplane model testing at Langley.

REENTRY TEMPERATURE

Flying within the bow shock is an important consideration because it means the Soviet spaceplane's overall reentry heating temperatures are several hundred degrees less than the maximum heating of larger vehicles—like the U.S. and Soviet shuttle orbiters—that have wings protruding outside the shock wave.

Velocity of the flow around vehicle surfaces within the shock is significantly less than the velocity of the flow immediately outside the bow shock. This enables the Soviet spaceplane to fly in a cooler reentry environment.

The flight requirements of the heavy shuttle vehicles dictate the use of delta shaped wings that, by their nature, protrude outside the shock wave and therefore require greater heating protection.

The spaceplane does require some high-technology thermal protection, however, and NASA analysis indicates the vehicle may obtain some of its protection by use of a smooth plastic-type coating that sublimates to dissipate heat as the reentry is flown.

U.S. reconnaissance satellite photography of Tyuratam shows multiple launch pads under construction for all of the large new space vehicles as well as extensive support facilities.

A vehicle assembly building comparable in size to the one at Kennedy Space Center has been constructed at Tyuratam and large cryogenic fuel storage facilities also are being built.

Reconnaissance satellite images of the cryogenic rocket fuel storage areas show them to be much larger than the storage capability at Kennedy now used for the shuttle, but originally built 20 years ago for the Saturn 5 program.

The Soviets have as many as nine aerospace and heavy machinery design bureaus working on this space buildup.

Beggs is skeptical about whether slush hydrogen is being planned for the large Soviet vehicles and whether the small spaceplane will actually result in a full-scale manned vehicle.

"Technically, the slush propellant would give quite an increase in capability because you can pack fuel in a given volume, but it also means that you have to design for lower temperatures and could have insulation problems."

Beggs also is skeptical about the spaceplane being scaled to a larger manned vehicle because the Soviets routinely fly a large number of aircraft prototypes that never go into production. He believes the spaceplane could be a technology demonstrator for the larger Soviet shuttle program rather than a separate manned element in the program.

In other Soviet activity, the three-man crew on the Salyut 7 station last week passed the 200-day mark on their mission as they unloaded the Progress 23 tanker/transport docked to the Salyut.

These are new unmanned Soviet space missions:

Earth resources satellite.—The Cosmos 1,582 film return Earth imaging spacecraft was launched July 19 into a 274 × 249-km. (170 × 155-mi.) orbit inclined 82.3 deg.

Military reconnaissance satellite.—The Cosmos 1,583 military imaging satellite was launched July 24 into a 412 × 354-km. (256 × 219-mi.) orbit inclined 72.9 deg.

Earth resources vehicle.—The Cosmos 1,584 spacecraft was the second Earth resources imaging spacecraft launched in late July. It was placed in a 268 × 193-km. (166 × 193-mi.) orbit inclined 82.4 deg.

Imaging reconnaissance satellite.—The Cosmos 1,585 imaging reconnaissance satellite was launched July 31 and placed into a 324 × 181-km. (201 × 181-mi.) orbit inclined 64.8 deg.

Missile warning satellite.—The Cosmos 1,586 missile early warning satellite was launched Aug. 2 into a 40,165 × 614-km. (24,957 × 614-mi.) orbit inclined 62.8 deg.

Geosynchronous orbit vehicle.—A Gorizont communications spacecraft, the tenth launched, was placed in geosynchronous orbit Aug. 2.

Photo reconnaissance satellite.—The Cosmos 1,587 military photo reconnaissance satellite was launched Aug. 6 into a 394 × 209-km. (245 × 130-mi.) orbit inclined 72.9 deg.

Ocean surveillance spacecraft.—The Cosmos 1,588 electronic ocean surveillance spacecraft was launched Aug. 8 into a 457 × 438-km. (283 × 272-mi.) orbit inclined 65 deg.

Earth research spacecraft.—The Cosmos 1,589 spacecraft was launched Aug. 8 into a 1,523 × 1,500-km. (946 × 932-km. (946 × 932-mi.) orbit inclined 82.6 deg. The parameters are similar to some previous geodetic missions.

Communications spacecraft.—A Molniya 1 military communications spacecraft was launched Aug. 10 into a 40,772 × 479-km. (25,334 × 479-mi.) orbit inclined 62.7 deg.

Earth resources satellite.—Another Soviet Earth resources vehicle was launched Aug. 16 into a 293 × 221-km. (182 × 137-mi.) orbit inclined 82.4 deg.

Senator MATHIAS. I see the red light is on me now, so I yield to Senator Pell.

Senator PELL. Thank you, Mr. Chairman.

Mr. Chairman, I would ask unanimous consent that a statement by Congressman Mel Levine, a sponsor of the companion bill, House Joint Resolution 536, be inserted in the record.

Senator MATHIAS. Without objection, it will be so ordered.

[Representative Levine's prepared statement follows:]

CONGRESS OF THE UNITED STATES,
HOUSE OF REPRESENTATIVES,
Washington, DC, September 10, 1984.

Senator CLAIBORNE PELL,
Senate Foreign Relations Committee,
Senate Dirksen Building.

DEAR SENATOR PELL: I understand that on September 13, the Senate Foreign Relations Committee will hold hearings on S.J. Res. 236, and in general, on the issue of East-West cooperation in space. As the House sponsor of a companion bill, H.J. Res. 536, I would like to submit a statement for the Committee record regarding the value of promoting U.S./Soviet joint ventures in space.

I appreciate the fact the Committee has seen fit to hold hearings on this timely topic. Thank you for your cooperation.

Sincerely,

MEL LEVINE, *Members of Congress.*

PREPARED STATEMENT OF HON. MEL LEVINE, A REPRESENTATIVE IN CONGRESS FROM CALIFORNIA

Mr. Chairman, I would like to thank you and the members of this Committee for holding hearings on the critical issue of U.S./Soviet space cooperation. Before we proceed with the irreversible, destabilizing, and costly development and deployment of space weapons, I believe that we should be aware of the consequences of such a policy and understand the alternative options before us.

This Administration has embarked on an unprecedented effort to weaponize our space program, a program which until recently was largely dedicated to peaceful exploration and cooperation with other nations. Today, however, the Reagan Administration is asking Congress to fund a new generation of anti-satellite weapons, and a space-based anti-missile defense system.

In proposing the development of these weapons, the Administration has signaled both the Congress and the Soviet Union that it does not intend to comply with the spirit and the letter of several space agreements which this country has signed. More than 100 nations, including the United States and the Soviet Union, have signed the Treaty on Outer Space which emphasizes that the study and exploration of outer space should be conducted for the benefit of all nations and prohibits the deployment of nuclear weapons in space. Additionally, the signing of the 1972 ABM Treaty, perhaps the most effective and stabilizing of all arms control agreements, prohibited the testing, development, and deployment of a space based missile defense system. In proposing development of a ballistic missile defense system, this Administration carries on as if this country has no prior agreements or policy commitments.

I am equally disturbed that despite offers from the Soviet Government, this Administration has not yet arranged to negotiate an agreement with the Soviets regarding the testing and deployment of anti-satellite weapons. We stand at a unique moment in time in which neither we nor the Soviets has a reliable ASAT weapon. This Administration does not fully appreciate the fact that unless we guarantee the protection of our satellites, international weapons verification will be jeopardized, and any move toward future arms control agreements stifled.

Preventing this Administration from proceeding with its plans to weaponize our space program is not enough, however. We must renew past agreements which resulted in peaceful and productive cooperative ventures between the United States and the Soviet Union. I am therefore encouraged by President Reagan's recent speech in which he indicated that the United States and the Soviet Union should improve their joint space rescue capabilities. In a letter to me, the State Department has reiterated the Administration's interest in this joint space venture, and has specified that a "space shuttle would rendezvous with the Soviet space station to practice procedures that might be necessary to rescue each other's personnel."

While space rescue appears to be the only proposal for a cooperative project now being considered by the United States and U.S.S.R., the Administration has also indicated to me its willingness to consider other cooperative projects as long as they are "mutually beneficial and scientifically sound." As the Administration is prepared to discuss pursuing additional joint space activities, I would suggest that our government immediately renew the 1972 space cooperation agreement, as called for in S.J. Res. 236, and in my companion bill, H.J. Res. 536, which 83 of my colleagues have cosponsored.

In the most immediate and practical sense, renewal of the 1972 space cooperation agreement would allow our two nations to consider a wide range of joint activities which are mutually beneficial and scientifically sound. By recommitting ourselves to this treaty, and thus reiterating our interest in the principle of space cooperation, we create momentum for engaging the Soviets in an ongoing dialogue regarding future activities and agreements. Without this agreement, there exists little coordination between ourselves and the Soviets, and a smaller likelihood that our space activities could ever continue to complement one another. Moreover, unless the space science community of both nations has a general understanding of the extent and direction of its country's commitment to space cooperation, it will be less inclined to participate in such joint activities.

As a result of the decade-long space cooperation agreement, our two nations have a successful history of working together in planetary exploration, space biology, and in joint manned and unmanned missions. These cooperative projects have not only expanded our knowledge of outer space but, while they were in effect, helped establish and maintain a continuous line of communications between ourselves and the Soviet Union.

Given the costs of space missions, space cooperation has and can continue to enhance the efficiency of our own space program by preventing duplication of experimentation and observation. Additionally, renewing the 1972–1977 space cooperation agreement would in no way hamper our ability to continue to work separately on our own space program.

U.S./Soviet space cooperation has received strong bipartisan support in past Administrations. President Nixon initially signed an agreement in 1972, authorizing joint space ventures between the United States and the Soviet Union. This agreement was subsequently renewed by President Carter in 1977. Unfortunately the Reagan Administration allowed it to expire in 1982.

It so happened that the space agreement and two other U.S./Soviet agreements (pertaining to energy science and technology) were all up for renewal in May 1982, five months after declaration of martial law in Poland. In response to the circumstances in Poland and to the continued Soviet presence in Afghanistan, the Reagan Administration decided to curtail overall participation in U.S./Soviet science and technology changes. Last summer, in testifying before this same Subcommittee, the Under Secretary for Security Assistance, Science and Technology, William Schneider, Jr., explained that "the primary criterion in the selection of those agreements which have been terminated was the date of their expiration, which in all cases was mid-1982."

Although I recognize this Administration's concerns about Soviet behavior, they are not sufficient reason to discontinue agreements which serve to reduce tensions and which result in significant benefits to the United States.

Past cooperative agreements have, in fact, served the interests of both nations. Joint cooperation between the U.S./U.S.S.R. culminated in 1975, when three American astronauts in an Apollo spacecraft linked in orbit with two Soviet cosmonauts in a Soyuz spacecraft. The Apollo-Soyuz mission was a success on many fronts. In the immediate sense, the two nations successfully demonstrated new technology for international space rescue capabilities.

Moreover, scientists from both nations were thrust into a multi-year working relationship which called for constant communication, and an open sharing of ideas, manpower, and technology. In 1973, for the first time, the Soviets admitted an American delegation to the previously top secret Soviet mission control center in order to coordinate communications and tracking. The following year, American astronauts visited the Soviet launch site at Tyuratam, and Soviet cosmonauts trained in Houston. Before the project was concluded, the Soviets and Americans had negotiated and signed 133 documents, an unprecedented achievement.

For the next several years, the United States and U.S.S.R. continued to make important gains in space cooperation. For example, the two nations pledged to continue to cooperate in a wide range of space activities to resolve problems of international law on the peaceful uses of space. Additionally, American scientists provided radar maps of Venus which were produced by a Pioneer spacecraft to help Soviet scientists select landing sites. In return the Soviets shared data from these missions with the United States. There has also been significant cooperation and continuing exchange of data regarding various biological experiments. Three satellites carrying test animals were sent into space by the Soviets in 1975, 1977, and 1979. The United States participated in these missions by providing the experiments and received, in return, the results of the experiments. Because the United States did not have a biosatellite program, and therefore could benefit at a minimum cost from the Soviet life sciences program, American participation in this program was especially beneficial to the United States.

The State Department recently reconfirmed the contention that U.S./Soviet space cooperation has significantly benefited our space program. In its final report to Congress on the scientific benefits of our Space Agreement with the Soviets, the State Department said that the "overall value of the scientific and technical information clearly favored the United States. For example, visits to the Soviet Union clearly benefited the U.S. scientific community involved with planetary exploration, especially since these visits coincided with the receipt of data and results during and after the March Soviet Venus lander missions."

In light of the findings of these studies, it is indeed tragic that the Reagan Administration has chosen to terminate virtually all space cooperation between our two nations. In addition, discussion of future cooperation in the field of planetary science was cancelled last year by this Administration. Working groups established under the 1972 space cooperation agreement to arrange for joint ventures in space meteorology, environmental studies, lunar and planetary exploration, and in space biology and medicine have also been disbanded.

Mr. Chairman, time is of the essence here. We must immediately shift the U.S. policy focus away from the weaponization of space toward international cooperative projects for peaceful purposes. Congress must send a message to the President that the current political situation demands a more cooperative attitude toward the Soviet Union regarding our respective space policies. On the most basic and significant level, official space cooperation will bring our two nations into a closer working relationship. Additionally, discussion of space cooperation provides both nations with a vast opportunity to explore a sphere that offers both nations mutual scientific and commerical benefits.

If we continue to prepare for war and anticipate conflict, I do not know how long we can continue to avoid confrontation. If we are committed to preserving peace then we must find an alternative to the weaponization of space. The alternative of cooperation not only serves the interests of the two superpowers, but all of humankind.

Senator PELL. Dr. Carol Rosin, president of the Institute for Security and Cooperation in Outer Space, has requested that her statement be made a part of the record. I would like to ask unanimous consent that her statement be inserted at this point.

Senator MATHIAS. Without objection.

[Dr. Rosin's prepared statement follows:]

PREPARED STATEMENT OF DR. CAROL S. ROSIN, PRESIDENT, INSTITUTE FOR SECURITY AND COOPERATION IN OUTER SPACE, WASHINGTON, DC, ON U.S.-U.S.S.R. SPACE COOPERATION AS AN ALTERNATIVE TO SPACE WEAPONS

SUMMARY OF PRINCIPAL POINTS

The attempt to formulate U.S./Soviet cooperative ventures will be undermined if Congress permits ASAT testing or approves "Star Wars" funding.

The political challenge is how to use cooperative ventures to convert the war industry into a space industry without weapons.

The industries are poised for conversion; the question is whether they will convert to the development of space weapons or the development of cooperative ventures.

The military can perform its national security function without space weapons.

The potential for jobs creation (and industry profits) through cooperative ventures is vast.

The European nations will take the leadership role in cooperative ventures if the United States fails to do so.

The strategically-flawed Strategic Defense Initiative (SDI) accelerates the arms race, contributes to superpower instability and contributes to record-breaking deficits.

We are at a pivotal point in arms control history. We can develop cooperative ventures in space or we can extend the arms race into space.

SDI proponents intend that "Star Wars" will be impossible to turn off by 1989. A little funding in 1984 is what they are counting on.

It is not too late to stop SDI. Cooperative space ventures are the alternative to more weapons.

SUPPORT SPACE COOPERATIVE VENTURES—NOT "ALSO" STAR WARS

I appreciate the opportunity to testify before the Senate foreign Relations Committee on legislation—introduced by Senator Spark Matsunaga and Congressman Mel Levine—aimed at encouraging U.S./Soviet cooperation in space as an alternative to a space arms race.

The Institute for Security and Cooperation in Outer Space supports Members of Congress who recognize that cooperative ventures are a crucial missing element in the formula for ending the arms race.

In my former jobs as a manager in a large aerospace firm and later as a defense consultant, I became aware that our industry—which embodies the genius of America's technological potential—faces the most important choices of yours and my lifetime. The first is whether or not we choose to extend the superpowers' arms race into space. The second—and intimately related choice is whether or not cooperative space ventures will be built as an alternative to such weapons. Although the second choice is the subject of these hearings, that issue cannot and should not be discussed in isolation.

As president of the Institute for Security and Cooperation in Outer Sp (ISCOS), I spend every day focusing on a two-part policy that is essential to th goal envisioned by those who support cooperative space ventures: (1) the goal of stopping both the testing of anti-satellite weapons (ASATs) and the funding for the Strategic Defense Initiative (SDI), and (2) the goal of creating paths not only to U.S./Soviet cooperation but also cooperation of other members of the international community.

Our analysis at the Institute convinces us that a strategy designed to promote cooperative space ventures cannot live side-by-side with a strategy supportive of "Star Wars" weapons. Any proposal to link these two fundamentally different programs is a "good news/bad news" situation.

The bad news is that if the Congress allows this Administration to proceed with its Strategic Defense Initiative—including its plans for testing ASAT weapons against an object in space (scheduled for after the November elections), it will undermine any possibility of cooperative U.S./Soviet ventures. The good news is that if ASAT testing and SDI funding can both be stopped—and we believe that they must be—cooperative ventures represent the best alternative for putting a literal lid on the superpowers' arms race.

For reasons that I will explain, I find it unfortunate that some proponents of space cooperation are now suggesting a compromise—that the United States proceed with both the Administration's SDI proposal and Senator Matsunaga's proposal for cooperative ventures. SDI proponents must be delighted.

Rest assured that these proponents have no intention of stopping with their initial $2 billion request (euphemistically labeled "research" in order to skirt the 1972 Anti-Ballistic Missile (ABM) Treaty's ban on missile defense systems "development"). Indeed, it is clear that this initial $2 billion is seen as only the down payment in a 5-year strategy designed to put into place in 1984 a weapons development momentum that this Administration (with good cause) believes will be impossible to reverse by 1989.

The purpose of our Institute is to educate decision-makers on this subject in the hope that you will join the efforts of those who see this costly new dimension of the arms race as: (1) fundamentally at odds with cooperative ventures, and (2) fundamentally flawed from both a national security and an arms control perspective.

The Soviets would interpret further SDI funding as an intention to develop a first strike capability. And to gain superiority they would break their current ASAT moratorium, devote their resources to an all out space war plan, and would likely terminate all endeavors toward the development of cooperative ventures.

Unfortunately, a dangerously complacent Congress is perilously close to allowing the debate on this issue to shift from "Is SDI a good idea?" to "Can or can't we do it?", "How many jobs will it create in my district?" and "How much money can the industry make?"

A sleepwalking American public is only now awakening to the dangerous path down which we head if we proceed with any aspect of this costly and frankly provocative space weapons program. Any proposal halting this Initiative would be met with widespread support—plus a collective sigh of relief from those who understand that the risks and the costs and, indeed, the stakes, are too high to proceed. The entirety of this program simply must be stopped, and stopped now.

The congressional challenge: Conversion of an industry

Those who oppose this escalation of the nuclear arms race—including that 90 percent of the Earth's population that is neither Soviet nor American—are learning that rational arguments against further escalation of the arms race are simply not enough, and that "protesting" has, at best, only a marginal effect.

The really crucial problem that must be faced how an entire industry (and more specifically the jobs and the profits it gener can be converted into a space industry rather than a space weapons industry. The danger is that SDI—if approved by this Congress—would set the stage for initial funding and job creation in the industries impacted by SDI. And the stage that would be set—as SDI proponents understand so well—is one which says that space weapons are a good idea. They are not.

The alternatives could not be more clear. One camp would convert the bulk of this nation's aerospace industry into an armaments manufacturing industry. The other suggests that cooperative ventures and the weapons-free development of space can create the same magnitude of industry profits (and constituent jobs). This second approach represents a more rational approach to long-term national security while also serving to better protect the Earth's biosphere from the devastating effects of a "nuclear winter."

Let me assure you that today the momentum is with those in the first camp. SDI proponents—with the able aid of this Administration—have thus far done a textbook perfect job of taking an inherently flawed concept and making it seem eminently logical and even reasonably affordable. Indeed, the President is now instructing the Congress that it is their "moral obligation" to approve SDI.

Advocates of SDI have suggested that SDI proponents should do just what the President is now helping them to do, namely to "steal the language and cause" of the arms control community by stressing the morality of space weapons in order to "keep the program alive in 1984 and to make it impossible to turn off by 1989." They suggest that "with appropriate political and emotional packaging", such an approach to "arms control" can be made to appear eminently logical "irrespective of its present technical or political merits."

Last month, more than a thousand industry representatives were provided a classified briefing on the lucrative contracts available to them (with their assistance, of course, in securing Congressional approval of SDI). A videotape is now being prepared to show our school-age children how space weapons will supposedly save them from nuclear weapons. And the list goes on.

But before addressing why SDI is such a totally flawed concept, let me first turn your attention to a crucial underlying political and economic issue: How to begin the conversion of the war industry into a space industry as an alternative to squandering our space industry's potential—including its many benefits for all of mankind—by incorporating it into the war industry.

How best to use America's technological potential

On the plague attached to America's Apollo 11 project left on the Moon was a simple motto: "We came in peace for all mankind."

While a corporate manager in the aerospace industry, I became aware (while working with Dr. Werner von Braun for four years) that the same industry that today builds high tech missiles and bombers could one day be devoted to either one of two equally profitable and job-generating tasks: they could continue to build weapons and simply convert to building their space-age equivalent (plus countermeasures) or they could build the technologies necessary for the joint ventures that you have heard so much about today (and which I amplify later in this text).

SDI proponents would have the industry believe that jobs and profits lie only down the first path. Nothing could be further from the truth (as I explained in my recently released book, "Space Careers" co-authored with Dr. Charles Sheffield, Vice-president of Earth Satellite Corporation). Indeed, if the Congress is foolhardy enough to allow SDI to be funded, the industry should recognize that (as with any military weapons program) it may ultimately be negotiated away anyway. Hopefully this hearing will help get that message across. My industry contacts tell me that they would far prefer to work on space systems than space weapons systems—they just are not yet being offered that alternative.

Imagine what the industry (and the military) could create if that $26 billion (the currently projected SDI 5-year funding level) were instead applied to cooperative ventures and weapons-free research and development. There would be more products, services and jobs than ever before as this Nation's technological elite develop the potential of space—cooperatively.

Today you have heard only the tip of the iceberg of space applications. As witnesses have told you, there are enough projects already on the drawing boards to create not only jobs and profits but also a better relationship with our global neighbor, the Soviets. Such an approach would also make us far better global neighbors to the rest of the 156-nation world community.

The United States doesn't need weapons in space, it needs better statesmanship regarding the uses of space. Today's weapons have effects that can linger for a period longer than all of recorded history. In such an environment, it is cooperation, not confrontation, that should be first and foremost on our space policy agenda. Far more than national security is threatened; the very health of the world's biosphere is at stake. Although the superpower nations have the right to protect the sovereignty of their man-made boundaries, the rights of Mankind dictate that the means used to protect those rights reflect the global responsibility that today's weapons imply. That is our moral obligation.

Our industries are poised for conversion; the only question is conversion to which type of space endeavor: weapons or cooperative ventures.

Conversion to cooperative space technologies would help achieve peace between the superpowers by:

(1) Reducing the risk of nuclear war,

(2) Building in interdependence and interrelatedness,

(3) Reducing fear, and

(4) Enhancing trust by the nature of working together.

(5) Enabling these high tech resources to instead be used to provide better economic conditions in both countries (and throughout the world).

The U.S. military services are in the perfect position to apply their strengths and skills toward collaborative security ventures—of a non-weapons nature. The crucial point is not to keep the military out of space; that seems unrealistic and perhaps even undesirable. Yet performance of their national security function need not include space weapons. Instead we can develop an earth-based joint space command post in conjunction with the development in space of a global security satellite monitoring system along with other methods for crisis control—all with the military's expertise and leadership.

Alternatives to the use of space technology for space weapons

One of the vital missing elements in the formula for achieving arms control is how to stop weapons production. Space provides the key—the missing element of the formula. The people in the military and in industry cannot simply stop working and making money—unfortunate but true.

They must be provided with a feasible alternative to what they are doing. The technology and its applications must be of a scale large enough to replace the political momentum that keeps this (and other) nation's weapons budgets not only intact but growing. The space issue gives us the time and place in which this goal could eventually be accomplished.

Since we must act quickly (before an irreversible momentum gets into place), I will simply suggest some projects that could begin immediately and urge you to design projects that meet your constituents' needs and interests. As a former educator, I also urge you to not overlook your children as a source for ideas . . . and for what they want in their future.

Suggestions include the following:

1. An International Satellite Monitoring System, with the United States providing the lead in this French-originated idea. The system could be administered by a new agency patterned on Intelsat or Inmarsat, in which both superpowers already participate. Potential applications include crisis monitoring; weather forecasting and storm warning; mapping; food, fiber and forest production monitoring and inventory; air, sea and space traffic control; global arms control verification; disaster watch; environmental pollution monitoring; resources exploration; data relay, etc., etc. A global service system could provide timely and useful information to world leaders.

2. With the Space Command in Colorado Springs and other space command posts being built around the world, we can build a joint military command post on Earth and in Space to reduce the danger of war by accident, miscalculation, misinterpretation or other unforeseen events. We could begin by utilizing existing facilities and sharing data from existing national systems. Eventually, the heart of the system could be a military command post in space, jointly designed, built and staffed. It could one day have its own dedicated surveillance sensors, jointly developed, to augment national systems. By having joint access to military information, we can prevent misunderstandings and provide better communication to reduce the danger of being brought into other conflicts. As a step toward this objective, the Institute urges the United States to invite military personnel from the Soviet Union and other nations to visit our Cheyenne Mountain complex.

3. To ease the cold war strain between the superpowers, we can encourage an immediate Shuttle/Salyut link-up, similar to the successful Apollo/Soyuz endeavor. The Soviets have a manned space station with no reusable transport system, and the United States has a reusable transport with no space station. Rather than rushing to duplicate each others' expensive capabilities, let us encourage joint ventures using existing superpower strengths.

4. We can urge the building of a long-range engineering project to eliminate existing space debris and minimize future build up.

5. A long-range project for mining asteroids may also prove feasible.

6. We could establish a transportation service to and from space stations (and possibly Earth's moon), including sustained human presence for scientific, educational, cultural and economic purposes.

7. Space probes to obtain information from Mars and other planets.

8. Space laboratories and hospitals to study the human aging process, effects of living in zero gravity, medicines and healing techniques.

9. Tourism (perhaps the first will now be a school teacher or a musician).

10. Space habitats, farms and schools.

11. Space-related commercial ventures.

The list can be as vast as the universe itself. Hundreds of thousands of men and women could work in military, technical, political, diplomatic, legal, economic, social, psychological, medical, educational, moral and other fields in multinational teams and organizations, with budgets shared by a steadily expanding group of participating nations.

In July 1984, the Congress passed legislation to create a National Commission on Space to study the future direction of U.S. space activities. Perhaps it is time to form an International Space Commission.

While awareness of the need for superpower cooperation in space is taking place in Congress, the "people" are not waiting for their decision makers; they are proceeding with small scale cooperative ventures of their own.

Though there are numerous ongoing exchanges of people and information (in spite of budget cuts), one current satellite project provides a perfect example of the kind of cooperation that we have the potential to create through already existing space-age technologies. Just 3 years ago, the first of several two-way, audio-visual satellite teleconferences took place between Moscow and Los Angeles. Two hundred thousand young people in Los Angeles and several hundred in Moscow could communicate, dance to each others' music, and yell "Good Morning America" and "Good Morning Russia" as they waved, saw and heard each other—using satellite link-ups and huge viewing screens. Soon, slow-scan equipment will make teleconferencing less expensive for inter-nation link-ups.

The Europeans challenge the U.S./U.S.S.R. for space cooperation leadership

If the Americans and the Soviets continue with the Reagan-initiated proposal to weaponize space, will the U.S. then try to sell its European allies and others on its intentions to establish space fortresses in and over Europe and other parts of the world? If so, what is the likely response?

The world community is already on record registering their concern over this new proposal to expand the arms race into the space over their own nations. Given the already strong interest in space cooperation in Europe, it seems quite likely that the Europeans, perhaps in conjunction with the "in-between" nations, will take the leadership position away from the U.S. and the U.S.S.R. and fashion their own cooperative space security efforts—with profound implications for superpower foreign policies.

In February 1984, French President Mitterrand spoke of a European space station equipped "to observe, transmit and counter any eventual menace" to European security. Italy and West Germany have announced plans for a joint European space station within the next 15 years.

Another challenge to the superpower domination of space will come in April 1985 when the French government in cooperation with European commercial interests, launches the Earth's most powerful earth-observation satellite, SPOT. Since the U.S. military currently classifies much of Landsat's information, SPOT's information-gathering capacity may render Landsat obsolete.

Why proceed with both "star wars" and cooperative space ventures?

"Star Wars" proponents insist that their Strategic Defense Initiative will make us more secure. Indeed, the President argues that this new generation of new weapons will reverse the arms race, take the hair-trigger off nuclear war, create superpower stability and serve as a less costly deterrent. In each and every case, just the opposite is, in fact, the truth. And each rationale cavalierly overlooks the fact that continued SDI development would contravene the 1972 Anti-Ballistic Missile (ABM) Treaty.

Consider the following:

1. Is SDI really a defensive system? More importantly, will the Soviets perceive it as such?

SDI proponents argue that peace would be secured not by the threat of retaliation but by a "High Frontier" defense. Yet even the most avid SDI advocate readily confesses that even after the expenditure of literally hundreds of billions in taxpayer money there is no possiblity of a perfect space defense. With an optimistic 90 percent effective system, those billions—and possibly trillions—may reduce the number of nuclear warheads that would make it into the United States from thousands to hundreds. Two hundred or less would destory this nation.

It also appears that ASATs and other SDI-related weaponry may pressure the Soviets another step closer to a "preemptive strike" defense mode. After all, why should the Soviets think that such a system is for any purpose other than taking out their satellites at the most critical moment?

2. Will SDI stop or reverse the arms race? No. If arms control is clear on one point it is that this argument can be expected from the proponents of any new weapons system. Each time that the weapons technicians promise us a large advantage (MIRVs highly accurate warheads, cruise missiles, etc.), the Soviets duplicate it. The inevitable and predictable result is simply another rachet of the arms race and yet another complicating factor in the arms control problem.

Strategically, how could it be otherwise? What if the Soviets should gain technological superiority in this "Star Wars" arms race into which SDI proponents would lead us? Wouldn't the Soviet's "success" drive us to develop a matching (or superior) technology?

As I pointed out in my May 1983 testimony to this Committee, in space technology there would be a "leapfrog of technologies, not a catch-up game like on earth"—all the more reason to stop this arms escalation before it develops to our strategic detriment.

Even assuming that the United States is able to retain its current technological superiority, how then can we reasonably expect the Soviets to agree to any significant arms control agreements knowing that their potential adversary could knock out their verification capability at any moment? In that context, doesn't even a "No First Use" declaration lose all relevance?

It appears that in return for what will likely turn out to be only a temporary technological advantage, the SDI proponents would undermine the likelihood of ever bringing the superpower nations to the negotiating table. Cooperative space ventures, on the other hand, provide a non-threatening context in which negotiations could and would begin.

3. Would SDI take the hair trigger off nuclear war and create greater superpower security?

Quite the contrary. Consider for a moment that the very reason for anti-satellite weapons (ASATs) is to destroy communication, command, control, intelligence and navigation equipment—those orbiting "eye in the sky" satellites that serve as the backbone of both nations' early warning and arms verification systems while also serving to reduce the likelihood of nuclear accident, miscalculation, misinterpretation, mistake or other unforeseeable events.

The effect of endangering this "feedback" capability is to move the Soviets another step closer to that most unstable of all strategic modes: "launch on warning." Today, the nuclear war decision-making time cycle is, at best, well under 15 minutes. How much more would the SDI proponents have us compress that reaction time? How much closer to a hair-trigger, launch-on-warning, use-it-or-lose-it basis would they have the superpowers operate?

And, of course, it increases the incentive to develop their preemptive strike capability. If our roles were reversed, such a strategic mode would seem equally "rational" from our point of view.

Indeed, it is a negotiating illusion to think that either side can gain a decisive military advantage over the other that will allow it to dictate the other's actions. Neither side can allow that to happen, and each is capable of preventing it. And any attempt to operate from that negotiating posture is provocative in the extreme. SDI is the very antithesis of stability.

4. Wouldn't it be worth the money just to do the "research"? Although SDI proponents speak in terms of "research" (permitted under the 1972 ABM Treaty), it is clear that much of the envisioned SDI-funded activities are really development (forbidden under the treaty). Indeed, Secretary of Defense Weinberger and other SDI proponents have already spoken of the need to "modify" the treaty.

Also, SDI countermeasures can be developed for a fraction of the cost of SDI-envisioned weapons (i.e., space mines, mirrors, decoys, etc). The price of ASAT weapons and other SDI-related weapons is simply too high—not only in terms of the hundreds of billions in better-used resources but also because the problem is that the real price for what is at best only a momentary military advantage is to jeopardize both current and future arms control agreements.

It should also be kept in mind that the United States tested the first ASATs (nuclear-tipped) in the 1960s. The Soviet rocket-launched ASAT testing has been less than 50 percent successful and, even if actually operational (which it is not), could not reach U.S. high-orbit satellites (thus the SDI proponents' insulting suggestion that the United States offer to negotiate on a ban of high-orbit ASATs—leaving only the Soviet low-orbit strategic satellites vulnerable).

The second generation of U.S. ASATs now scheduled for testing against an object in space are launched from under an F-15 jet fighter (the first non-verifiable ASAT mode). At the first generation of ASATs development, verification is possible (contrary to SDI proponents' claims to the contrary). To proceed with this new ASAT

weaponry seriously jeopardizes the possibility of arms control (due to lack of verifiability).

Since August of 1983, the Soviets have been participating in a unilateral, verifiable ASAT moratorium. They submitted a U.N. draft treaty banning space weapons and announced their willingness to dismantle existing ASATs and negotiate a verifiable treaty.

5. Won't space weapons get rid of nuclear weapons? Won't they move the nuclear threat away from Earth?

No. Space weapons are connected to earth weapons and offer no steps to eliminate nuclear weapons. They only enhance the perceived need for additional nuclear build-up and increase the likelihood of a preemptive attack or an accident. In fact, the Soviets are likely to want more nuclear weapons (see discussion above). And it is clear that all weapons systems are interrelated; if anything. Earth is more endangered due to the additional instability inherent in the SDI "philosophy" (see discussion above).

6. Isn't it too late to stop the Star Wars momentum? No. The timing is perfect to stop it now—as we create the cooperative ventures that replace the need for space weapons and that simultaneously create the job and profit opportunities sought by industry.

Conclusion: The choice is literally yours

It is crucially important to understand that this is a pivotal point in history. A choice is now available and is only available now. The most important element necessary to insure that cooperative U.S./Soviet ventures can exist is the overall philosophy with which America proceeds into space.

Will we choose to create a context that is provocative and confrontational or will we go into space cooperatively and with plans designed to develop "the unlimited frontier" for its peace-promoting and peace-keeping potential? Is space to be developed as a battleground to further threaten life or is it to be used to nurture and sustain life?

The time to make that choice is now, during the final weeks of this Congress. Next year will be too late. Before the affected industries gear up for the development of this new generation of war hardware—with all the profit and job retention pressures that weapons contracts always imply—let us redirect those skills and resources into positive, weapons-free ventures—before it is too late.

The international community is both worried and outraged that the superpowers would take their arms race into an area that belongs both to no one and to everyone. In a United Nations vote, all nations except the United States (with Great Britain abstaining) voted to ban space weapons. Approximately 200 prominent United States and Soviet scientists have signed a petition to ban space weapons. Public interest groups are forming. Congressman George Brown has formed a Coalition for the Peaceful Uses of Space. The networking of alternatives is taking place. Yet this plea has thus far gone unheeded.

The only chance now lies with the Congress where, hopefully, a more rational—and a more representative—expression of American sentiment will be heard (a recent Yankelovich survey shows that 76 percent of the public agrees that the U.S. is at least partly to blame for the deterioration in relations with the Soviets; 50 percent of the respondents under 30 years old believe that an all-out nuclear war is likely within the next 10 years).

Everything is in place for an expansion of peaceful cooperation as an alternative to military confrontation. The people want a change yet most do not yet know that the U.S. and the Soviets have worked together on successful cooperative space ventures in the past, including the Apollo-Soyuz link-up, biomedical life science exchanges and recent two-way audio visual cultural and scientific teleconferences. U.S./Soviet space search-and-rescue missions are committed. In addition, more than 200 U.S. corporations are now doing business with the Soviets. And President Reagan just this week announced that American farmers could continue to sell grain to the Soviets.

Lists of cooperative space ventures can be created. A joint Mars mission is an excellent one, as long as "Star Wars" budgets do not accompany it. Even a small amount of SDI funding would eventually eliminate the Mars project (recall what happened to the Halley's Comet project) as SDI would preempt the resources.

The European Space Agency and other countries are planning to deploy an international navigation monitoring system. The world's people are networking in citizen outreach endeavors. In short, the desire is there. The technology is there. All that is missing is the political will.

To eliminate the chances that cooperative space ventures will be jeopardized or eliminated, all SDI funding must be stopped and applied to cooperative space ventures that will provide security. We must also join the Soviets in their ASAT moratorium and begin negotiations that will result in a ban of space weapons.

The legacy we leave our children should not be the lunacy of taking the arms race into outer space. It is terrible enough—and costly enough—right here on Earth. If space is to be used for national security purposes, then let it be done not in a combative way but through international joint space ventures as an alternative to an arms race in space.

The Soviets have agreed to ban weapons from space. We have numerous examples of ending disputes with our former "enemies". Why not with the Soviets now.

There would be more jobs, more profits and more happy people in your district than during any cold or hot war. I urge you not to compromise on this crucial issue. If you don't "go for it" now, we will not have another chance. SDI proponents are fervently hoping that you will sit back and allow this genie out of the bottle, knowing full well that you will not be able to get it back in again. You need not let that happen.

I am one who believes that when someone has an opportunity to make a change for the better they also have a responsibility to make that change. I urge you to exercise that responsibility—now.

Senator PELL. I would also ask that the record be kept open for other statements that might be submitted.

Senator MATHIAS. Without objection, it is so ordered. Let me ask you how long you think we should keep the record open?

Senator PELL. For 3 days.

Senator MATHIAS. Three days is reasonable.

Senator PELL. I would like to ask each of the panelists a question, and I would ask that they respond in a sentence or two. The question is, do you favor congressional approval of Senate Joint Resolution 236? Obviously, I imagine that you all do, but I would like to have a digest of your thoughts in a couple of sentences that we can use in our own discussions. We are trying to move ahead on this.

Dr. Sagan.

Mr. SAGAN. I believe Senate Joint Resolution 236 provides a politically and economically viable alternative to the strategic defense initiative, whose net impact will be a dramatic decline in the security of the United States.

Senator PELL. Thank you very much.

Mr. Friedman.

Mr. FRIEDMAN. Yes, I do favor the adoption of the joint resolution. The need for Government sanction, alluded to earlier, and Government approval of contact is very important because of the Soviets' heavy dependence, of course, on government. All of their scientists essentially operate with government approval or in government institutions, quite unlike our own scientists.

They are not free to travel or to engage in any of these bilateral activities without government approval, and there have been several instances in which the amount of cooperation and data exchange has been reduced because of government inhibitions. Opportunities for Soviet scientists to work in American institutions in the last few years has been reduced as a result of this specific treaty not being renewed.

So I think it is quite important that its renewal be earnestly considered.

Senator PELL. Thank you.

Dr. Burke.

Mr. BURKE. I, too, favor the proposed resolution. I feel that avenues of communication between the United States and the U.S.S.R. are so limited now that any opening must be a good thing. My own experience has been that when one does have a cooperative agreement with them, that in fact they gradually get used to the idea of easing up the restrictions on our visits there, and their scientists' visits here.

People who ordinarily were never permitted to travel outside the Soviet Union were finally allowed to do so. Their scientists, I think, appreciate the opportunity to actively be part of that world scientific community that they know they are a part of, and I think that U.S. scientists greatly appreciate the opportunity to interact with their best scientists, who are really among the world's sharpest minds, particularly in theoretical astrophysics.

Senator PELL. Thank you. Dr. Masursky.

Mr. MASURSKY. I favor a joint resolution, because they watch us very carefully, and I think this will help us in observing their program. Second, that we can avoid wasteful noncoordination, so our own exploration will be expedited, and we are sure we are not duplicating unnecessarily work. And third, we may be able to engender more effective cooperation and do things that we cannot now do curselves.

Senator PELL. Thank you. There are two analogies that come to my mind here. One is in connection with the importance of opening up alternative channels of communication, track 2 diplomacy, or whatever we wish to call it, when the main political channels seem to be closed off. That is the case today.

An example would be when a man has a bypass. You find other arteries start taking over for the one that is clogged. And in this case you find the main political channels seem very clogged. Therefore, we need to use more of these other channels.

Or another analogy that has often struck me is that of Gulliver and the Lilliputians. There was Gulliver, held down by hundreds of little thread, and he could not move. Well, by the same token, if you think, instead of Gulliver, of a god of war, held down by a whole lot of little agreements and little contacts, and little relationships, that tying down also can have a slowing down effect on his more warlike instincts, I hope.

Let me look at it from a negative viewpoint. What do we stand to lose if we do not move down this road? I would like to get a specific one or two-sentence reply from each one of you.

Mr. SAGAN. We lose the opportunity to broaden and deepen the quality of the scientific work for reasons that the other panelists, especially Dr. Masursky, have stressed, and we lose an important opportunity to build several dozen threads binding the two nations together and forging a hopeful future for the human species.

Senator PELL. Thank you.

Dr. Friedman.

Mr. FRIEDMAN. That is a very hard question. It is kind of like asking what do you lose if you do not do science? If you try nothing you do not know what you lose. I am in agreement with Dr. Sagan that we lose nothing by going ahead, and, in fact, there is a lot to gain by going ahead. I cannot be certain of what we lose by not going ahead, but I think that the losses would clearly be there.

Senator PELL. Thank you.

Dr. Burke.

Mr. BURKE. In my view, the principal loss is likely to be the initiative in international scientific cooperation. The Soviets are moving aggressively. They have a number of cooperative space projects with the European scientists that are very good projects indeed. If they conduct their affairs well, I think that they will probably occupy the central position in international science eventually.

Senator PELL. Thank you.

Dr. Masursky.

Mr. MASURSKY. I think what we lose is, people on both sides are clever enough to find some way of maintaining contact, and there are contacts going on. We help them. They help us. So we will manage somehow to find a way. If we move ahead, that will be enormously increased, and many other things that are outside of our reach now will not be done.

Senator PELL. Thank you.

Now, another question to which I would be interested in your reaction, as would the Senate, is whether or not in your view the Soviets would respond favorably to an initiative on our part to enlarge these contacts. Dr. Sagan.

Mr. SAGAN. Yes. I think there is very convincing evidence, at least by the testimony of virtually every Soviet senior space scientist that we talk to, that such an American initiative would be greeted with a great sigh of relief over there.

Senator PELL. Would it be greeted with relief by their political overseer?

Mr. SAGAN. I doubt if they would have told us what I just said if there had been opposition at a higher level.

Senator PELL. I think you are right.

Dr. Friedman.

Mr. FRIEDMAN. There is an enormous change that has gone on in the Soviet planetary program and space sciences in general, and that is the openness of planning and the internationalization of their own missions. The VEGA mission which they are doing to Venus and Halley's Comet includes some nine nations, not all of them just from the Eastern bloc, but with some Western European nations, and even some informal American involvement.

There is being planned for the future a very ambitious mission to Mars to rendezvous with the Martian satellite Phobos. This is a change. It is that indication, the openness of planning and their own internationalization of missions, which I think signals very strongly that they are amenable to—more than amenable, I think, they are encouraging—this type of internationalization.

Senator PELL. I think my time has expired, and as a good example of restraint, I will not press the two of you remaining for a reply.

Senator MATHIAS. Thank you, Senator Pell.

Senator Matsunaga.

Senator MATSUNAGA. Thank you, Mr. Chairman.

First, I wish to compliment each of the witnesses for their incisive and extremely enlightening testimony. The Congress needs your expertise in order to make sound policy judgments in this im-

portant area and we are extremely grateful for the contribution you have made today. I was particularly interested in the conclusion, which you all share, that basic communication between Soviet and American scientists is so critically dependent on government policy, especially on the need for a formal agreement. That was also the conclusion of a dinner I had the pleasure of hosting on May 7 of this year at the Brookings Institution, attended by about a dozen American and Soviet scientists. The dinner was part of a continuing effort to educate myself on this subject and I was struck then, as I am today, by the importance of the United States-Soviet space cooperation agreement for space science exchanges at every level. The Soviet scientists especially indicated that unless the agreement that we permitted to expire in 1982 was renewed, they would have difficulty engaging in joint projects with us.

Do each of you agree with that observation?

Mr. SAGAN. [Nods affirmatively.]

Mr. FRIEDMAN. [Nods affirmatively.]

Mr. BURKE. [Nods affirmatively.]

Mr. MASURSKY. [Nods affirmatively.]

Senator MATSUNAGA. I see you all agree. My father, who happened to be a Shinto priest, used to teach me through Japanese maxims and adages, and one of the maxims he said I might apply in the field of politics was this, and those who are expert in Japanese may understand this.

[Whereupon, Senator Matsunaga spoke in Japanese.]

Senator MATSUNAGA. That means, if you try to chop your foe's head, you may have your own head chopped off, but if you befriend your foe, you increase your own strength. I think this is a case where that maxim can truly apply, and on the basis of your testimony, it appears that you all agree.

Now, only last week three Soviet cosmonauts in the Salyut 7 space station broke the world endurance record for manned space flight that had been held by another team of Soviet cosmonauts. As of September 5, the three Russians had been in orbit for 211 consecutive days, or more than 7 months.

My two-part question to all of you is this. First, might the Soviet experience in long duration flight be of assistance in our efforts in that direction, in view of the shuttle's current maximum stay time of only 10 days? And, second, do you see any indications as to what use beyond the Salyut 7 the Soviets might be planning to apply their long duration flight experience, a trip to Mars, perhaps?

Dr. Sagan.

Mr. SAGAN. Yes. As I tried to indicate earlier, it is certainly of use for all future applications in long duration space flight, the two most obvious of which are permanently crewed installations in low Earth orbit and missions to nearby celestial objects, of which Mars comes most readily to mind—because the Moon or an Earth-crossing asteroid take much shorter periods of time to get there.

The only obvious objective for human flights that requires 7 months or more are nearby planets. Venus is much too hostile for a human visit, and that leaves only Mars.

Senator MATSUNAGA. Thank you.

Dr. Friedman.

Mr. FRIEDMAN. Yes, a permanent manned or womaned presence in Earth orbit does not require a permanent man or woman there. It only requires an ability to go up and come down from Earth orbit and resupply. So it is unlikely that long duration flights are being undertaken just for Earth orbital purposes alone. At least no one has identified the reason to do it that way, or for that to be the end objective of that type of research.

The flights to planets involving human crews, human activities on the planets, at the Moon, maybe on near Earth asteroids, and certainly at Mars has been stated by their commentators as a goal for their program. Mars is the most likely place in the solar system, and has long been seen as a probable goal for the Soviet Union's space program.

The technological developments, and in particular the long duration activities that they are doing seem consistent with those goals.

I think that they have accomplished an awful lot toward it, and I think we have also with our active program of planetary exploration. It is clear that those technologies could come together, as has been suggested earlier, in efforts to send humans to other planets.

Senator MATSUNAGA. Thank you.

Dr. Burke.

Mr. BURKE. I am less of an expert in this particular area than our two previous witnesses, but it would seem to me that even for a more modest program such as the space station, this sort of data is useful for your mission planning. I speak not as an expert, but merely am trying to use common sense.

If you want to have men in space for periods longer than the brief shuttle stage, I think it would be prudent to have experience well beyond the length of time you actually plan to have men in the space station in case of emergencies or just plain conservatism, not trying to stress the human physiology beyond its limits.

Senator MATSUNAGA. Thank you.

And from the technical expert, Dr. Masursky?

Mr. MASURSKY. I have heard an interesting statement from the Soviets. The exchange in the bio area has been the most vigorous of all of our exchanges, and they say to us, of course you are interested in that, because we have all the data, and we are quite willing to share that with you. So their perception of the exchange process is slightly different from ours.

I agree with Carl that other than emergencies, the most obvious thing is a manned Mars mission. We have talked about a return sample mission which we may do to set the stage for a manned Mars mission, and the Soviets have a voluminous literature pointing to that as a long-range goal.

And since they work very hard at establishing these long endurance records, it seems to me wholly consistent that they have such a plan.

Senator MATSUNAGA. In your prepared statement, Dr. Masursky, you noted that the Soviets are planning a mission to the Mars moon called Phobos in 1988.

Mr. MASURSKY. Yes.

Senator MATSUNAGA. And that we are planning a scientific Mars mission for 1990.

Mr. MASURSKY. Yes.

Senator MATSUNAGA. You then suggest that we cross-calibrate instruments and coordinate our activities in other ways in order to increase scientific return. Given the lead times for such missions, when should we begin talking with the Soviets if we are to obtain the mutual benefits you suggest?

Mr. MASURSKY. Now.

Senator MATSUNAGA. Now. Right away.

Mr. MASURSKY. [Nods affirmatively.]

Senator MATSUNAGA. That would not be quite possible without the renewal of the agreement which expired in 1982.

Mr. MASURSKY. We can do it with great difficulty. We can try to get the right people to the right international meetings to talk to each other. We could do it very directly, very easily, if we had such an agreement.

Senator MATSUNAGA. But the passage of the Joint Resolution 236 would help?

Mr. MASURSKY. It would help greatly.

Senator MATSUNAGA. Thank you.

Dr. Friedman, the Planetary Society, I believe, was one of the sponsors of the Case for Mars Conference. Would you briefly summarize the Case for Mars?

Mr. FRIEDMAN. Several years ago, when the future of the planetary program was in doubt, despite the successes of the late 1970's, there was a large community of people who said that Mars studies should be going on, and future planning for future missions to Mars should be going on.

NASA was not doing any such study, so the Planetary Society tried to keep that activity going by building on what was then a student group's interest at the University of Colorado, and suggesting that it be expanded to many universities around the country, sponsoring courses, research projects, and seminars related to the future of Mars exploration.

That community of studies has developed. They are directed to the possibility of future human activities at Mars and a series of steps through automatic missions leading to human missions have been studied to look at the feasibility of that.

I am pleased to say that that study has received favorable attention by NASA, and they are interested now in doing their own studies on the future of Mars, and since, of course, governments are going to carry out programs, this is a very important point. It also emphasizes the need for the Senate joint resolution. Governments carry out space exploration, not private groups, and while the Planetary Society can stimulate things, and while university scientists can help in exchanges, governments are going to carry on space programs, and government-to-government cooperation and sanction is needed.

Senator MATSUNAGA. I see my time is up, Mr. Chairman. Thank you.

Senator MATHIAS. Thank you, Senator Matsunaga.

We are under considerable time pressure as there is going to be a quorum call for a cloture vote at noon, and we have two more witnesses to go. I do think the committee would be remiss, however, if we did not ask this panel one further question.

The Washington Post this morning reports that the Office of Management and Budget is recommending to the President that we reduce by roughly 50 percent the appropriation for SARSAT, which is a joint United States-Soviet search and rescue satellite program.

Could anyone give us a quick opinion as to the virtue of the OMB recommendation?

Mr. SAGAN. No virtue apparent.

Senator MATHIAS. This is an ongoing cooperative program which exists in spite of the absence of a cooperation agreement. Do you feel reducing the appropriation would be a serious step backward? I cannot lead the witnesses any more than that, I do not think. [Laughter.]

Mr. FRIEDMAN. It is hard to understand. Actually, this seems quite out of character with recent spoken support for encouraging cooperation. There have been many statements saying they will permit a certain amount of scientist-to-scientist interaction and cooperation on benign projects, but when it comes down to specific programs getting approval, we find this sort of thing happening, so it is hard to reconcile.

Now, there may be other explanations, but they are not apparent.

Senator MATHIAS. I will put the article from today's Washington Post in the record, so that this reference will not be obscure in the event someone should by chance decide to read the record.

[The article referred to follows:]

[From the Washington Post, Sept. 13, 1984]

UNITED STATES-SOVIET VENTURE USING SATELLITES IN RESCUES MAY BE DISRUPTED

(By John M. Goshko)

Opposition from the Office of Management and Budget threatens to disrupt the only current U.S.-Soviet space venture, a program that uses satellites in rescue operations.

The program, known as SARSAT, uses polar-orbiting satellites to find lost aircraft and vessels in distress. It has been credited with rescuing 247 people during its two years of operation.

Now the program has become entangled in a dispute about its costs that could subject President Reagan to charges that he is more interested in saving money than lives and is not sincere about his professed desire to find areas of scientific cooperation with the Soviet Union.

OMB Director David A. Stockman contends that the program's projected costs exceed the president's budgetary guidelines. Stockman seeks cuts he says will save more than $300 million over four years. Such cuts would reduce the program to half of what had been agreed tentatively with the Soviets.

Stockman has insisted on the cuts, saying, "I believe it is imperative that [the responsible agencies] negotiate only those international agreements that are consistent with the president's policy and budget."

On the other side are the National Aeronautics and Space Administration; the Commerce Department, parent agency of the National Oceanic and Atmospheric Administration, which is scheduled to assume responsibility for the U.S. part of the program from NASA; the State Department; the Air Force and the Coast Guard, all of which argue that Stockman's insistence on budgetary austerity in this instance could hand the Soviet Union a sizable propaganda victory over the United States.

In particular, these agencies argue, exposing the United States to potential accusations of sacrificing lives to budget cuts could be embarrassing to Reagan while his attitude about dealing with the Soviet Union is an issue in the presidential campaign. Earlier this month, on the first anniversary of the Soviet shooting down of a

civilian South Korean airliner, the administration demanded that the Soviet Union take steps to cooperate with other countries in making civilian travel safer.

Rep. James H. Scheuer (D-N.Y.), chairman of a House subcommittee on natural resources and the environment, has announced that hearings on the matter will take place next week. Scheuer said in a statement that "After the downing of Korean Airlines flight 007, I should think that the last thing that the Reagan administration would want to do is give the Soviets an opportunity to demonstrate to the rest of the world that their humanitarian priorities are in better order than those of the United States."

A meeting is to be held in Leningrad in early October that had been expected to result in the signing of a U.S.-Soviet accord to extend the rescue program until 1990. The proposed agreement would obligate the United States and the Soviet Union each to maintain two orbiting satellites equipped with detection sensors throughout the six-year period.

During the experimental phase of the program, the United States launched one SARSAT satellite 16 months ago, but it prematurely failed in June.

Other SARSAT satellites are scheduled to be launched by the United States in November and next summer. That would meet the U.S. commitment under the Leningrad agreement.

"At first," said a State Department official, "it seemed like one of those apple-pie-and-mother deals that no one could object to." He noted that information provided by Soviet satellites resulted in almost all of the rescues so far, although those who were saved were Americans, Canadians and West Europeans.

Then, on July 26, Stockman sent a letter to Commerce Secretary Malcolm Baldrige noting that the administration's last three budget requests had asked for only one SARSAT-type satellite. Thus, Stockman said, even though Congress appropriated money for two satellites, the OMB wants one eliminated to save $300 million from 1985 to 1989.

OMB's position drew objections from the other agencies that the proposed Leningrad agreement was based on scientific calculations that two American and two Soviet satellites are needed if the program is to achieve a high rate of rescues.

L.K. Mossemann, a deputy assistant secretary of defense, also said in a letter to the OMB:

"If the U.S. goes to Leningrad in October and can only commit to having a single satellite in orbit, we are setting ourselves up for some interesting propaganda from the Soviets in the fall time frame.

"Conversely, I would think that the administration would go out of its way to assure that this meeting is successful. Regardless of the outcome of the arms talks, this would be one concrete and demonstrable expression of U.S.-Soviet cooperation to which President Reagan could point with pride."

These arguments do not seem to have had an impact on OMB, although an agency spokesman said this week that Stockman is waiting to hear from Baldrige before taking a final position.

Senator MATHIAS. We are joined by the distinguished Senator from Delaware.

Senator BIDEN. Mr. Chairman, I have only one question. I know you are in a rush, and I would like to begin by apologizing to this distinguished panel for not being here earlier.

I am ranking member of the Judiciary Committee, and we just dealt with a few little issues that the chairman would be interested in, like the Hobbs Act, constitutional amendment to balance the budget, nothing controversial, and that is why I was tied up.

I understand from staff that you have covered pretty thoroughly everything, but there is one area that is the one I usually get hit on by individuals who criticize and or question my promotion of cooperation, and that is the risk question.

Now, if you have covered this, please tell me, and we will go on. How would you assess the risk of technology transfer? As harmful to our national interest, our national security interest, as a result of the renewed cooperation along the lines you have been discussing today? Have you discussed that yet?

Senator MATHIAS. Yes, we have.

Mr. BURKE. Briefly, the opinion of our workshop was that technology transfer with respect to space cooperation—well, the concern is probably minimal, because the approach to instrumentation is very conservative. You use well proven technologies, and of course after a certain length of time the lead is kept up by the United States not by copying our old things, but developing new things which do not reach the space hardware stage for quite a few years.

Senator BIDEN. How would you assess the risks in terms of your own specialties?

Mr. BURKE. In my specialty, no risk.

Mr. FRIEDMAN. I cited a Congressional Research Service report which said in the space science area there had never been instances of technology transfer being found, and I also in my prepared statement mentioned a few areas where we have a lot to pick up from them, and indeed in some areas in planetary exploration they can be teaching us some things.

Mr. MASURSKY. There is technology transfer, but it is our custom that both the spacecraft and all the instrumentation is documented in public documents, so we give elaborate explanations of exactly how we do everything, or nobody will believe the data, so the risk of technology transfer is essentially zero, because we are very careful to publish the documentation on everything we do.

Senator BIDEN. Thank you, Mr. Chairman. I have no further questions.

Senator MATHIAS. Thank you very much, gentlemen.

Senator MATSUNAGA. Mr. Chairman, are you dismissing the panel?

Senator MATHIAS. Yes, I am concerned that we do hear our two other witnesses. Our remaining time is short.

Our next witnesses are Charles Horner, Deputy Assistant Secretary for the Bureau of Oceans, Environment, and Science, Department of State, and James Morrison, Deputy Assistant Administrator for International Affairs of the National Aeronautics and Space Administration.

Senator PELL. Mr. Chairman.

Senator MATHIAS. Senator Pell.

Senator PELL. Mr. Chairman, I would amend my request that the record be kept open only until the close of business today in order that we may have a better chance of accepting testimony and finishing the record.

Senator MATHIAS. Without objection, the request is amended. The record will be closed at the close of business today instead of after 3 days, as previously ordered.

Senator MATSUNAGA. Mr. Chairman.

Senator MATHIAS. Senator Matsunaga.

Senator MATSUNAGA. Mr. Chairman, I have the transcript of a videotape sent to me, expressly for this occasion, by author and scientist Arthur C. Clarke. Few, if any, can speak about space with greater authority, or vision, than this remarkable man, who, among so many other things, is the father of the modern communications satellite, which effectively ushered in the space age. Dr. Clarke believes so strongly that space should be used, as he puts it, for "technological decency" rather than "technological obsceni-

ties," that, when he heard of this hearing at the last minute, he videotaped a statement at his residence in Sri Lanka and rushed it here by courier. He wanted to be here personally, to present his views, and this was the closest thing to it. I commend Dr. Clarke's eloquent statement to all the members of the committee. As you will note, he is particularly supportive of a joint United States-Soviet mission to Mars. Mr. Chairman, I ask unanimous consent that the transcript of the videotape sent to me by Dr. Clarke be included in the record at this point.

Senator MATHIAS. Without objection, it is so ordered.

[The material referred to follows:]

[Video presentation to the Committee on Foreign Relations, U.S. Senate, Sept. 13, 1984]

A MARTIAN ODYSSEY*

(By Arthur C. Clarke, Chancellor, University of Moratuwa, Fellow of King's College, London)

VIDEO PRESENTATION—(15 MINUTES)

The videotape was made on a UMATIC cassette (PAL, Lowband). The presentation follows the text closely, omitting the footnotes. The following video inserts were made at the appropriate places:

Jacket of "1984: Spring"
Title page of U.S.S.R. Beam Weapon Report
GCA Team (c/q Luis Alvarez)
Dr. Tom Paine
"2010" flight badges
General Alexei Leonov & A.C.C.
Sputnik
Leonov book—Stafford portrait and inscription.

Senator Matsunaga, distinguished Senators—I very much wish I could appear in person before your committee. Despite my well-known slogan "Don't commute—communicate!" I would have gladly made the long journey from Sri Lanka to be with you; but in a little over 2 weeks I also have to address the Pontifical Academy of Science on "The Impact of Space Exploration on Mankind." On the very day of your Senate Joint Resolution 236 deadline, October 1, I hope to raise many of its points with the leading Russian (and Chinese) scientists who will also be present at the Vatican.

May I first, Mr. Chairman, deal briefly with space weapons—a subject which has concerned me ever since the Royal Air Force Quarterly published my essay "The Rocket and the Future of Warfare" in 1946.[1] Somewhat later, in August 1982, I presented an updated version, "War and Peace in the Space Age," to the UN Committee on Disarmament in Geneva. The following month it was inserted into the Congressional Record by Representative George Brown,[2] and I refer you to what I devoutly hope is the final version in *1984: Spring*. I have also read a large fraction of the megawordage generated on the subject—including the unclassified summaries of the Fletcher Report, and its fascinating Soviet counterpart.[3] I have also talked with many of the experts involved—hawks, doves, and those who, like myself, might be classified as anxious falcons.

There can be no doubt that ICBM's could be intercepted and destroyed, even at ranges of several thousand kilometers, by projectile or beam weapons. But it could only be done at gigantic expense, by dedicated crews of highly trained scientists and engineers. A 50 percent success rate against a modest salvo would be impressive; a 90 percent one would be astonishing, and I doubt if any informed person really believes that such a figure is possible.

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*I have proudly borrowed this title from the classic short story by Stanley Weinbaum (1902–35), whose other memorial is an 80 kilometer-wide crater, lying between Wells and Burroughs, at 245 degrees West, 66 degrees South. (NASA "Atlas of Mars.")

[1] Reprinted in "Ascent to Orbit" (John Wiley, 1984) pp 71-9.

[2] Congressional Record Sept. 21, 1982.

[3] "Strategic and International-Political Consequences of creating a Space-based Anti-missile System using Directed Energy Weapons." (Institute of Space Research, Moscow, 1984).

Even if a 90 percent kill rate could be achieved, what would that imply? It has been pointed out that a full-scale thermonuclear exchange would be equivalent to "World War II once a second, for the length of a lazy afternoon." [4] So if a ballistic missile defence system was a brilliant success, it might merely give you World War II—every 10 seconds. Either way, the result would make "The Day After" look like an optimistic exercise in wishful thinking.

Though these are of course only personal guesses, I do have some relevant experience. Forty years ago I was in charge of the most advanced radar system then in existence. It took the best brains of MIT—one went on to win a Nobel Prize—to keep it running. The Star Warriors are talking about systems hundreds of times more complex, whose failure would be immeasurably more catastrophic.[5]

For a critique of the more far-fetched schemes of "orbital fortresses" I would like to put on record a letter I wrote to the AIAA's Astronautics, ironically praising an article entitled "The Coming Weapons" for "catching to perfection the authentic Strangelovian delight in technological obscenities." (Annex A.)

Let us now talk about technological decency. Fifteen years ago at the Cape, when we had finished cheering the first men on their way to the Moon, I saw the Vice President of the United States turn to Walter Cronkite and say that we could put a man on Mars by the end of the century—and "we should do it * * * because the people want something to look forward to as an exciting objective." That sentence echoes a much more ancient saying that might well serve as a motto for your Committee: "Without vision, the people perish."

Could we put a man on Mars by the end of the century—now only 1 year further away than the launch of Apollo 11? Let me give the views of a man who, perhaps better than anyone, can answer that question.

With appropriate serendipity, Dr. Tom Paine, NASA Administrator for the critical years 1968–1970, has just sent me the paper "A Timeline for Martian Pioneers" he delivered at the University of Colorado in July. Here is his prediction for the period beginning 1995—repeat, 1995:

"The decade opens with a triumphant Soviet expedition to Mars, including docking scenes at Phobos with spectacular extra-vehicular activities * * * that dominate TV. The President of the United States receives a Golden Fleece from an elderly senator for relinquishing America's scientific pre-eminence to the Soviet Union. In response he orders the Vice President to overhaul the American space program; she begins by firing the NASA Administrator for lack of boldness. * * *"

Dr. Paine has his tongue in his cheek, of course, but he is also deadly serious. When it is ready, the U.S.S.R. will go to Mars. Why are its cosmonauts making space endurance records with times approaching those required for the Earth-Mars round trip? You don't need that capability, for missions this side of the Moon!

Sooner than they imagine, Americans will have to ask themselves: "Do we stand aside, when the Soviet Union heads for Mars? Do we go it alone? Or do we go with them?"

I admit my bias—indeed, my interest—in this area. As you doubtless know, the novel "2010: Odyssey Two" describes a joint U.S.-U.S.S.R. mission—though to Jupiter, not Mars—and at this very moment Peter Hyams is filming it at MGM/UA. The novel is dedicated to Cosmonaut General Alexei Leonov, the first man to walk in space, and commander on the Apollo-Soyuz rendezvous. He was delighted to know that the ship is named after him: "Then it will be a good ship!" he exclaimed, when I told him this, in his apartment at "Star Village."[6] He was not quite so happy at sharing the dedication with Academician Sakharov; indeed, I am currently in disgrace in the Soviet Union, now that someone has noted the extraordinary coincidence that all seven Russians in "2010" are named after well-known dissidents.[7]

You may not remember that the Apollo-Soyuz mission was itself directly inspired by a Hollywood movie, "Marooned." Frankly, one of my purposes in writing "2010" was to start people thinking seriously once again about such co-operation.

I am not so naive as to imagine that this could be achieved without excruciating difficulty, and major changes in the present political climate. But those changes have to be made, sooner or later, and I commend your committee for its courage in recognizing this fact.

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[4] Carl Sagan: "Cosmos" (Random House, 1980) p 321.

[5] For some ominous lessons about the reliability of sophisticated military equipment—and its human operators—under actual combat conditions, see the record of the Falklands War.

[6] See "To Russia, With Love * * *" in "1984: Spring" (Del Rey).

[7] Though perhaps not well-known enough. Despite my warnings, and his cheerful claim to have "sanitised" the text, my Moscow friend and editor failed to spot these curious coincidences—and has accordingly lost his job. I feel both embarrassed and guilty.

Most of those changes will have to be made in Moscow, and may have to await the long-overdue extinction of the Kremlin dinosaurs. But not all the fault lies in the U.S.S.R.; painful adjustments will also be required nearer home. In this context, please see my letter to General Graham (Annex B), answering a circular sent out by his High Frontier organization after the shooting down of Korean Flight 007.

Now, to quote one of Stanley Kubrick's favorite remarks: "The only important question is what to do next." In this case, what we must do next is to strengthen and extend any existing space agreements. For example, the combined U.S.-U.S.S.R.-Canadian-French "Search and Rescue Satellite" (SARSAT) has already saved scores of lives, on the high seas and in the Arctic. It has received nothing like the recognition it should have done; if the public knew more about it, there would be a demand for more programs of this kind.

One might be—when its implications are fully explored—the International Monitoring Satellite,[8] which could help to dispel the present poisonous political atmosphere by at last achieving President Eisenhower's dream of "Open Skies." I was happy to see a step in this direction with the release of the satellite photographs of the Soviet aircraft carrier under construction, and have a motto for the IMS—"Peace Through Truth." Of course, many nations would object to Big Brother watching them from space—but here on the ground most law-abiding citizens are quite happy to have TV cameras surveying high-crime areas. And let's face it—Planet Earth is a highcrime area.

Unfortunately, the United States has missed the opportunity to join the international fleet of space probes that will soon encounter Halley's Comet. Perhaps the storm of criticism that will then ensue—there may be a Golden Fleece awarded to the President well in advance of Tom Paine's scenario—may have the salutary effect of focussing attention on this failure of nerve. Spring 1986 may be Sputnik time again.

But though unmanned space missions are essential and often highly cost-effective, they do not fire the imagination. And, contrary to what some scientists may have told you, in the long run it is the manned missions that will be the more important. Unfortunately, no-one can predict whether that run will last for centuries, or mere decades. Almost certainly it will exceed the attention span of even the most enlightened Administration.

I have just been listening to an historic and inspiring sound from the past—the applause of Congress as President Kennedy cried "We choose to go to the Moon!" One day the United States will return to the Moon. That will be exciting and important; but it will no longer be pioneering. The Moon, though an essential stepping stone to space, is only the offshore island of Earth. But Mars—a planet as large as our own, in terms of land area, is the first of the New Worlds.

Only 8 years from now it will be exactly half a millenium, since three tiny ships sailed forth from Spain, to change the history of our species. And three is about right for the smallest practical Mars expedition—one unmanned cargo vessel, and two manned ships, either able to carry both crews in an emergency. The cost would be less than that proposed merely for research into anti-ICBM systems—let alone the bill for their actual deployment, which would be orders of magnitude greater. Even those who think that such expenditure is necessary will surely deplore such a tragic diversion of resources.[9]

So is it absurdly optimistic to hope that, by Columbus Day 1992, the United States and the Soviet Union will have emerged from their long winter of sterile confrontation? That would be none to soon to start talking seriously about Mankind's next, and greatest, adventure.

When we said goodbye in Star Village, Alexei Leonov—who is a very good artist—gave me a copy of his book "Life Among Stars." In it are the sketches he made during the Apollo-Soyuz mission, including excellent likenesses of his American colleagues.

The portrait of Tom Stafford is autographed as follows: "To my dear friend Alexei Leonov—many thanks for your friendship and wonderful cooperation—we have opened a new Era in the history of man. Tom Stafford, July 18, 1975."

General Stafford—over to you.

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[8] See "War and Peace in the Space Age" ("1984: Spring").

[9] Of course, some research into ballistic missile defense is obviously essential to prevent—or perhaps discover—technological surprises. Fifty years ago a situation arose which has a striking lesson for today. On Jan. 18, 1935 the British Air Ministry's Director of Scientific Research asked Dr. Robert Watson-Watt if it was practical to develop a "death ray" against German bombers. Whilst proving that this was beyond current technology, Watson-Watt discovered something much more useful—radar. "History never repeats itself—but historical situations recur."

[Annex A]

FEBRUARY 17, 1983.

The EDITOR,
ASTRONAUTICS & AERONAUTICS, AIAA,
New York, NY.

DEAR SIR: I'm afraid that Allan Simon's brilliant parody, "The Coming Weapons" (November 1982) may miss its target. Far too many people will take it quite seriously—especially the aptly-named "Crackpot Realists" who flourish in the Pentagon and the Kremlin.

They'll adore the article, because it catches to perfection the authentic Strangelovian delight in technological obscenities. But anyone who is even partly sane will realise that the world described—though theoretically possible—would have a half-life of about 24 hours. Imagine a household containing a family, every member of which is armed with hand-grenades, ready for use at the slightest disagreement. That is an exact parallel of the world so eloquently described by Mr. Simon.

Fortunately, there is now a growing realisation that Mankind has reached the end of the line as far as weapons are concerned. Outside Hollywood and the video game arcades, "Star Wars" are indeed fantasy, and only political solutions can save us. (If we deserve to be saved: perhaps a species that has accumulated ten tons of explosive per capital has already demonstrated its biological unfitness beyond any further question.)

There have been times and cultures in which it was unthinkable (and frequently unwise) for a gentleman to appear in public without a weapon. In civilised societies, that need has passed—though there are still many pathological individuals in whom the want still exists. I am indebted to A.E. van Vogt for the slogan, which I have changed by merely one word: "The right *not* to bear weapons is the right to be free."

What now applies to individuals must one day apply also to nations . . . who, after all, are only collections of individuals. (Auden:—"There is no such thing as the State.") And for better or for worse, human nature is infinitely changeable—something else not understood by the above-mentioned Crackpot Realists.

If we wish for peace, we must prepare for peace. Though the opposite may have been true in an age of spears and swords, it is folly in the age of nuclear weapons. (So, I am afraid, is the Gandhian philosophy of passive non-resistance, superficially attractive though it appears. Ditto unilateral disarmament—though not carefully planned unilateral reductions of armament.) Even "defensive" military systems, with the possible exception of purely reconnaissance ones, are equally futile, because they are based on the same fallacy of security through one's own strength.

An excellent proof of this will be found in General Graham's "High Frontier" study, doubtless familiar to many of your readers. Whether or not it is technologically sound in all its details (I wouldn't sleep too well under the "protection" of a point defense system designed to destroy a warhead one second before it reaches the target) is immaterial. The report is valuable both as a lucid criticism of MAD, and (unintentionally) as a "reductio ad absurdum" proof of the impossibility of effective security through military means. But I salute General Graham and his colleagues for their attempt to define the present dilemma, and to escape from it.

At this point you will doubtless be asking: "OK., Mister Wise Guy—what's your solution?" Well, for a beginning, I suggest serious consideration of the French-proposed International Satellite Monitoring system, supported last December by 126 nations at the U.N. (11 abstentions, including the U.S.; 9 No's, including the U.S.S.R.) For further details, see U.N. Document A/AC 206/14 of August 16, 1981, and my address to the U.N. Disarmament Committee in Geneva, August 31, 1982. (Read into the Congressional Record by Representative George Brown, September 21, 1982.) I also enclose an excellent paper by Brenda Curtis: "Space Technology: For Military Escalation or Global Development?", presented to the NGO's at UNISPACE 82, which unites this project with the valid aims of the High Frontier advocates.

In the 1960's, reconnaissance satellites destroyed (though too late, alas!) the myth of the "missile gap". Before that, to quote President Johnson: "We were building things we didn't need to build; we were harboring fears we didn't need to harbor."

We are still doing that, on a far greater scale—and have no other choice while there are plausible grounds for such fears. (Saryshigan, Semipalatinsk . . .) But an international monitoring system, by helping to eliminate unnecessary fears, and pinpointing the sources of legitimate ones, could be a giant step towards a safer world.

When I suggested this last June in Moscow at the Institute of Space Research, someone made the sarcastic comment: "Perhaps the French hope to sell the equipment." I'm sorry I didn't think of the right answer in time: "So what?"

In the long run—no, the very short run—we have to become intelligent mammals, not turn ourselves back into armored dinosaurs. To complete that quotation from Auden: "We must love one another or die." And it's very hard to love people you don't like—especially when many of them are demonstrable SOB's.

But the alternative is a lot worse.

Sincerely,

ARTHUR C. CLARKE.

[Annex B]

OCTOBER 22, 1983.

Lt. Gen. DANIEL O. GRAHAM,
High Frontier, Washington, DC.

DEAR GENERAL GRAHAM: Thank you for your letter of September 19, which has just reached me in Sri Lanka.

Unfortunately, it represents a point of view which is in some respects an exact replica of the very one you (so rightly) criticise. American paranoia is almost as dangerous to the world as Russian paranoia. I say "almost", because one hopes that it is limited by the democratic process. And to be fair to the Russians—an exercise they make more and more difficult—one must admit that, like the Jews, they have earned their paranoia the hard way.

I shared your feelings of horror and outrage when I heard the news of the Jumbo jet disaster, and my own immediate reaction was fury at those responsible. I might also say that I felt exactly the same way towards America's good friend President Marcos when his principal opponent was murdered in Manila. But it is an elementary principle of law that innocence must be assumed until guilt is proved. A rush to judgement can delay and even prevent final justice. Over-reactions can arouse unjustified sympathy for those who are indeed guilty and deserving of punishment.

To be specific, your letter contains the sentence "Is cold-blooded, premeditated murder of 269 innocent people without provocation rational behavior?" The simple answer to that, of course, is "No". But it now seems more and more probable that your statement is the exact reverse of the truth. The Russian action was almost certainly hotblooded and unpremeditated. Those 269 victims might still be alive today had it indeed been "cold-blooded". There is a wise saying: "When an international lawyer enters the room, the temperature falls ten degrees." For the present, let us stop shouting at each other until there has been time for an impartial investigation.

I am not blaming you for the use of such provocative phraseology, because you were only echoing the remarks of President Reagan and Ambassador Kirkpatrick, and had every right to assume that their statements were based on accurate information. However, it has now been tacitly admitted by the State Department that there is (as yet) no evidence to prove that the Soviets knew what kind of plane they were destroying. They should have done so, of course, and at the very least they were guilty of incompetence. But far from being "premeditated", I suspect that the shooting-down was the panic reaction of a junior commander who is now feeling extremely sorry both for himself and his victims.

On the face of it, the Korean jet tragedy shows a very close parallel with the destruction of a civilian airliner by the Israelis when it strayed into sensitive airspace several years ago. I would make a small bet that at the time Pravda accused the Israelis of "coldblooded, premeditated murder". The difference between the two incidents is that the Israelis apologised and made compensation. We still await even the first from the U.S.S.R., and there seems even less hope of the second.

But to accuse the Russians of being murderous psychopaths is not merely foolish, but counter-productive; it will only make them even more bloody-minded and determined to live up to their image. The Soviet leadership is tough, dedicated, unscrupulous and often brutal. Yet even at the highest level there are honorable men whose co-operation we need, and who should not be antagonised by blanket denunciations--especially if they are untrue.

Not long ago I was in the office of a senior Russian general at the very moment when a complex operation for which he was responsible was reaching its climax. To my considerable surprise, he spent fifteen minutes giving me an impassioned lecture about the terrible things we were doing to the environment. (The Sierra Club would

have been proud of him.) Such people may be dangerous adversaries; but they are not murderers, and we have to share the world with them, whether we like it or not.

So a little more cold-bloodedness, please. Then perhaps we may survive to be warm-blooded again, on those happier occasions when it is more appropriate.

Sincerely,

ARTHUR C. CLARKE.

Senator MATSUNAGA. Mr. Chairman, early this summer, I solicited an opinion on United States-Soviet space cooperation from the dean of European space scientists, Dr. Hubert Curien. At the time I wrote him, Dr. Curien was Chairman of the Board of the European Science Foundation, an equivalent of our National Academy of Sciences; he was Chairman of the Council that oversees the European Space Agency; and he was Director of the National Center for Space Studies, the French equivalent of NASA. Since then, Dr. Curien has been elevated to a position in the French cabinet, as Minister of Science and Technology. Mr. Chairman, Dr. Curien's very significant letter includes a wholehearted endorsement of Senate Joint Resolution 236, and I ask unanimous consent to include it in the record.

Senator MATHIAS. Without objection, it is so ordered.

[The letter referred to follows:]

CENTRE NATIONAL D'ÉTUDES SPATIALES,
June 26, 1984.

Mr. SPARK M. MATSUNAGA,
U.S. Senator, Hart Building, Washington, DC.

DEAR SENATOR MATSUNAGA: I appreciate your informing me of your efforts to have the space cooperation agreement between the Soviet Union and the United States renewed and a fresh lease of life given to cooperation between the scientists of those two countries.

In the pursuit of its space programme, France is privileged to have close ongoing relationships with both the United States and the Soviet Union which have proved richly rewarding for us.

First of all, because they afford us an opportunity of participating in very worthwhile missions, but also because we are able thereby to establish closer and more open human relationships between scientists, regardless of national barriers. Despite the vagaries of the political climate, relationships between scientists remain deep and strong. To sever them on the pretext that Governments may be at odds on other issues is, to my mind, a mistake. Discarding what does or what can work is no way of improving what doesn't.

Scientists all over the world long for the free international exchange of ideas. Such exchange, when it is based on a pooling of programmes chosen from amongst the most ambitious of their kind, should be of particular benefit to mankind.

For instance, a joint initiative taken recently by the U.S. National Academy of Sciences and the European Science Foundation is a very promising one: the best specialists on both sides of the Atlantic met together in order to define what seemed to them the most desirable planetary missions for the years ahead. If, in future, such cooperation could also involve the Soviet Union still greater benefits would accrue.

I therefore congratulate you, Senator, on your initiative and I hope you may be heard by your country's authorities. I express this hope without reservation, convinced as I am that striving to promote better understanding between scientists throughout the world can in no way be regarded as interfering in the specific politics of each of our nations, matters which are, of course, outside my competence.

Yours sincerely,

H. CURIEN.

Senator MATSUNAGA. I also ask unanimous consent, Mr. Chairman, that a statement in the form of a letter from Dr. Thomas A. Paine, a former administrator of NASA and chief administrative officer of Northrop Corp., now an active and an extremely knowl-

edgeable proponent of Soviet-United States space cooperation that aims toward a manned mission to Mars, be included in the record.

Senator MATHIAS. Without objection, it is so ordered.

[The letter referred to follows:]

THOMAS PAINE ASSOCIATES,
Los Angeles, CA, September 6, 1984.

Senator SPARK M. MATSUNAGA,
Chief Democratic Party Whip, U.S. Senate, Hart Building, Washington, DC.

DEAR SENATOR MATSUNAGA: Arthur Clarke sent me a copy of your letter to him of August 13th on U.S.-U.S.S.R. Space Cooperation, and his response dated September 13th: A Martian Odyssey—Statement to the Committee on Foreign Relations, United States Senate. Since his response contained a quotation from a recent paper of mine, I thought you might like to have the enclosed whole paper: "A Timeline for Martian Pioneers," presented at the Planetary Society's "Case for Mars II" conference at the University of Colorado.

Arthur refers to the Apollo-Soyuz joint space flight. The attached history describes how I initiated this program with the late President of the Soviet Academy of Sciences, Academician Mstislav Vsevolodovich Keldysh. As you can see, we started with NASA's plans for the future exploration of space, and asked the Soviets whether they saw areas where cooperative programs might be of mutual benefit. The initial response was suspicious, slow and cautious, but with persistence and patience significant success was finally achieved. I believe that the result was a more open Soviet program, a dramatic demonstration to both nations of the practicality and benefits of detente, and, for a while at least, a somewhat safer world for us all.

The coming Extraterrestrial Century, as outlined in my paper on the settlement of Mars, will present leaders of the United States and the Soviet Union with many opportunities for cooperative enterprises. Not all programs should be international, but many space ventures, like the Intelsat communication satellite network, are inherently global. Unlike terrestrial conquests, the conquest of Mars is not a "zero-sum game" in which my victories are your defeats; victories on the space frontier are victories for all mankind.

With best personal regards,

DR. THOMAS O. PAINE.

Senator MATSUNAGA. Mr. Chairman, in preparation for this hearing, I asked that the Congressional Research Service prepare a report summarizing past and present American and Soviet interests in manned missions to Mars. The report, prepared with great competence by Marcia Smith of the Science Policy Division, makes fascinating reading. It offers convincing evidence that a Mars mission has been technically feasible for some time, that leaders of both nations have recognized the overwhelming logic of collaboration for manned space missions on that scale, that our space programs are complementary for the pursuit of such objectives, that both nations have been pointing toward Mars since the 1950's, that both have been held back mainly by costs which could be reduced sharply by cooperation. Mr. Chairman, in the interest of printing costs, I suggest that this report not be made a part of the hearing record but that it be a part of the committee record of references, so that those interested may be able to avail themselves of this extremely important document.

I have one final request, Mr. Chairman. I know you will agree wish me that the Office of Technology Assessment has done a wonderful job in response to the request from yourself, Senator Pell and myself. I wish to record my gratitude to the members of the OTA staff, and to the scientist participants in the OTA symposium, for their superb effort.

Senator MATHIAS. I would like to join with the Senator from Hawaii in an expression of that appreciation.

Senator MATSUNAGA. And I might point out that the CRS report was compiled and prepared by Marcia Smith of the Science Policy Division, and it makes fascinating reading, truly. I wish to record my compliments to them.

Mr. Chairman, a prominent figure who has turned his attention to space in recent years, with typically fruitful results, is James Michener, whose novel "Space" is a fictionalized history of the space program that is also a prodigious feat of historical research. Mr. Michener has since dedicated a large portion of his time to space issues. Mr. Chairman, I ask unanimous consent to include in the record a letter to me from James Michener that contains important insights and suggestions regarding our future in space, which Mr. Michener also believes ought to be pursued in a context of United States-Soviet cooperation rather than confrontation.

Senator MATHIAS. Without objection, it is so ordered.

[The letter referred to follows:]

THE UNIVERSITY OF TEXAS AT AUSTIN,
THE GENERAL LIBRARIES,
Austin, TX, September 12, 1984.

Senator SPARK M. MATSUNAGA,
U.S. Senate, Hart Building, Washington, DC.

DEAR SENATOR MATSUNAGA: All persons interested in the development of outer space follow with keen attention your attempts to guide its use into constructive channels. For some years now the proper utilization of space has been a major concern of mine, and I constantly hope that ways may be found to bring international order into this vital arena. Each year that passes, each new invention alters the old rules and presents new challenges. I hope the nations may be capable of adjusting to these changes and accepting the new possibilities.

I think you ought to stress with your people that the rate of change is now so rapid that neither you nor I can possibly imagine what the capacities will be by the year 2000, and if through fear we are caught hibernating in some wintry cave of limited vision we shall be overrun by facts and outdistanced by others who have adjusted to those facts.

Manned travel to the planets is now practical. Permanent settlements on the Moon can be established at any time we wish. Low-orbiting space stations are already in existence to a degree and their proliferation is limited only by budget. I have acknowledged for some time of the ability of any major nation which wishes to spend the money and ingenuity to put into orbit vehicles of powerful military might. And unmanned exploration of the farthest reaches of our galaxy are possible.

Senator, I am speaking only of what we can do right now with the inventions we already have in hand. If we project our present rate of development ahead fifty years, only the most imaginative mind would come close to what will be possible. Some time ago I spent a summer listening to great experts theorize on what the world of space was going to look like by the year 2010, and they conceded that they could not extrapolate much beyond the next ten years. Nor would they speak with confidence even within that narrow perimieter, for they conceded that things might develop of which they had at that moment no cognizance.

If the speed of invention is so great, I think it incumbent upon us to spend careful thought on what we ought to be doing right now to utilize present capacity and then to pave the way for greater experimentation and achievement later on. That, it seems to me, is the obligation of any major nation.

I am peculiarly involved in such thinking, because I serve on a board whose responsibility it is to combat attempts by the Soviet Union to discolor the truth insofar as international policies are concerned, and I work diligently to protect the reputation of my nation. So I can certainly not be charged with any sentimental favoritism toward the Soviet Union. My job is to monitor her misbehaviors.

But when it comes to the long haul of science and the accomplishments of the future in space, I find myself ardently hoping that the fruitful bi-national cooperation which started with Apollo-Soyuz can be revived, because at some future time,

perhaps before the end of this century, such international ventures will be commonplace and we might as well get started correctly now.

I do not see anything contradictory in this recommendation. Of course we are at odds with the Soviet Union on many basic points, and we must protect ourselves for to do otherwise would be irresponsible or worse. But we must also inhabit the Earth with the Russians and share in whatever forward steps are taken. This is a tricky co-responsibility, but I believe the United States is alert enough to manage it. I have always been guided by the military principle that when the first gun is fired in warfare, advisors should start holding consultations regarding the terms under which peace can be restored.

Now as to the specific targets of co-operation, my imagination cannot be as free-wheeling as that of scientists who are experts in these fields, but three possibilities dominate my attention: (1) Further exploration of the Moon, with the reminder that the Soviets got there first with their cameras and their rovers and thus had the privilege of naming most of the features on the far side; (2) manned exploration of Mars, which would be a major effort requiring enormous planning and much more than a year of absence from the Earth; and (3) extensive further exploration of the solar system, including concentration on problems relating to the Sun whose power ensures our existence on Earth.

I am sure there are other possibilities which would yield equally significant results, but I must leave their identification to others, as I am not qualified to give advice.

I am, however, informed on the role of exploration in human existence. Once a frontier is negotiated there becomes, I believe, a categorical imperative to pursue its exploration to logical limits. People who follow this path acquire understanding and a control of their environment. Universities which behave in this manner become great. Nations which have this as a guiding principle develop new skills, aptitudes and mind-sets which enable them to prosper in comparison with other nations which lag behind. People and nations are not obligated to adopt every innovation, and prudent ones choose wisely lest they lose their historic headings; but they are obligated to know what's happening.

Conversely, those people, universities and nations which shy away from investigation of possibilities condemn themselves to a second-rate existence which can be satisfying in some respects but which misses the great challenges of their time. I am awed by the heavy penalties organizations pay when they fail to keep abreast of what is happening, and in my work I see the remains of many nations which failed. I do not want to see this happen to the United States.

A final difficult question remains. Could the United States conduct these space explorations alone? Yes, but it would be more fruitful, I believe, if we cooperated with the Soviet Union and with other space-competent nations in joint enterprises where scientific enlightment is the goal. We shall be driven to isolated experimentation in those cases where military competency is at stake, but I do not believe that we should allow that necessity to dominate the world's behavior in space.

I therefore endorse heartily Senate Joint Resolution 236 and pray that it will become a guiding policy statement for our nation.

Sincerely,

JAMES A. MICHENER.

Senator MATHIAS. Thank you very much.

Mr. Horner, I think you have observed the time limitations under which we are proceeding.

We direct that your statement and Mr. Morrison's statement will appear in full in the record, and would ask you to summarize them as concisely as you feel possible.

STATEMENT OF CHARLES E. HORNER, DEPUTY ASSISTANT SECRETARY FOR BUREAU OF OCEANS, ENVIRONMENT AND SCIENCES, DEPARTMENT OF STATE

Mr. HORNER. I would just take a moment to summarize the principal points of the prepared statement. On the 27th of June, the President spoke to a group of people who had been convened by the Woodrow Wilson Center of the Smithsonian, and reiterated the interests of the administration in doing what seemed reasonable and

useful in establishing better ties and communications with the Soviet Union and also with the Soviet people. At the same time he alluded to the problems, past and present, which have to weigh in any decision about concrete programs.

In this general area, the United States made a specific proposal to the Soviet Union concerning the development of a simulated rescue mission and about which we have not received a substantive response as yet. But that proposal, so far as we know, is still being considered by them.

In addition, and in response to the general tenor of the discussion of the public witnesses this morning, I suppose there are one or two points that we ought to recall. The first is the relationship between the existence of Soviet-American cooperative projects in space on the one hand and what influence, if any, that has had on Soviet geopolitical and military aims and behavior.

It is a matter of historical record that at the time of the Apollo-Soyuz project, for example, there was considerable expansionist activity by the Soviets. As to the main point that seemed to emerge this morning, this high point of cooperation had little if any influence either on the Soviet military buildup generally, or specifically, on the testing and deployment of the Soviet antisatellite weapon system undertaken during the same period. This is not to say that one causes the other, only that it is not self-evident that one can substitute the one thing for the other.

The only point I want to make on the subject of the resolution itself is this: We are of the view that it is premature to raise the subject of renewal of the governing space agreement at this time, and for several reasons. The first, of course, is that we have yet to receive a response to the proposal we have made for a simulated rescue mission. Also—and my colleague, Jim Morrison, could speak more directly to this—I think we want to develop a better understanding of the priorities over the next decade in our own space program and whether those would be the same or different from those which are identified in the older agreement.

[Mr. Horner's prepared statement follows:]

Statement by Charles E. Horner
Deputy Assistant Secretary for Scientific
and Technology Affairs
Department of State

Before the Senate Foreign Relations Committee

September 13, 1984

Mr. Chairman:

I appreciate the opportunity to discuss with the Foreign Relations Committee today the Department of State's views on S.J. Resolution 236 "Relating to cooperative East-West ventures in space as an alternative to a space arms race". As you know, the United State has recently made several proposals to establish a better working relationship with the Soviet Union, including a simulated space rescue mission. Before describing that proposal and the State Department's views on the provisions of S.J. Res. 236, I would like to offer some observations on the nature of past efforts in outer space with the Soviet Union.

In a three-year period from 1972 to 1974 eleven separate agreements were signed between the United States and the Soviet Union which provided for cooperation in a variety of fields. There was one general agreement, the Agreement for Cooperation in the Fields of Science and Technology, otherwise known as the S&T Agreement and ten other agreements targetted at specific areas of interest.

Not the least of these was the Space Agreement. The Apollo-Soyuz project was one of the cooperative efforts under the Space Agreement. The logic behind the development of all eleven agreements was that they would be beneficial to the United States by providing us with scientific gains, while guarding against inequality of benefit. In a sense, formalized government-to-government sponsored exchanges with the Soviet Union in the scientific field were very much a part of the detente diplomacy in the early seventies.

The high point of the bilateral agreements occurred in 1975 as the volume of exchanges reached 2,284 individual visits both ways and the Apollo-Soyuz mission became a reality in July of that year. The year 1979, however, marked a downturn in the volume of exchanges under the agreements. Relations between the United States and the Soviet Union were becoming more strained and many American scientists boycotted the exchanges because of the 1978 trials of Yuriy Orlov and Anatoliy Sharanskiy. The most destructive blow to the exchanges came, however, with the Soviet invasion of Afghanistan. Following the Soviet intervention in Afghanistan and the subsequent internal exile of Andrei Sakharov over his protest of that event, we cut back our cooperative science and technology exchanges with the Soviet Union significantly. In 1982, in response to Soviet endorsement of Polish

repression, we allowed three bilateral agreements to lapse, including the one on space, thus suspending the formal cooperative relationship in this area.

The first observation I wish to make about the nature of our experiences to date in this area is that, in the Department of State's view, cooperative projects in space have not had any direct influence on Soviet geopolitical and military aims. For example, the Apollo-Soyuz project did nothing to restrain the Soviet Union's adventurism in Angola, or the invasion of Afhanistan or to prevent the massive and unprecedented buildup in Soviet strategic arms which took place in the 1970's. It did nothing to prevent -- and I think this is particularly relevant to the Committee's consideration of S.J. Res. 236 -- the testing and deployment of the Soviet anti-satellite weapon system in the same period.

The Department believes that cooperative projects in space must be carefully formulated in the context of our overall relations with the Soviets; they are not separable. As the President remarked in his June 27, 1984 speech to participants in the Smithsonian's Conference on U.S.-Soviet Exchanges, when Soviet actions threaten the peace or trample on standards fundamental to the civilized world, the United States cannot be silent; we must have ways short of military threats that make it clear to Soviet authorities

that their actions do matter and that some actions inevitably affect the quality of bilateral relations.

Nevertheless, U.S. reactions do lead to a decrease in contacts with the people and government of the Soviet Union and this is a dilemma for the United States. It is a dilemma that is not easily resolved.

Thus, while the United States deplores violations of the human rights provisions of the Helsinki Final Act and the plight of Dr. Sahkharov, Yelena Bonner and other courageous people in the Soviet Union, the United States also wants a better working relationship with the Soviet Union. The Department of State has made it clear to the Soviet Union on numerous occasions that only when there is an improvement in Soviet behavior can our relationship deepen. Nevertheless, the United States has encouraged the Soviet Union to join with us in a major effort to establish a better working relationship with each other, and we have made comprehensive and specific proposals to improve the US/Soviet dialogue, including in the area of space where we have proposed a joint simulated space rescue mission, one of the areas noted in S.J. Res. 236 for potential cooperation.

This proposal we have made envisages cooperation between NASA and Soviet space officials on a joint simulated space rescue mission. A Space Shuttle would

rendezvous with the Soviet space station to practice procedures that might be necessary to rescue each other's personnel, though details of the proposal would have to be worked out. In response, the Soviets chose not to address the substance of the proposal, but made clear they did not consider substantive discussion appropriate for the time being at least.

S.J. 236 makes specific reference to the desirability of reviving the space agreement. Given the Soviet attitude toward the simulated space rescue proposal, I believe that it would be premature to address the possibility of a new overall space agreement or even project-specific agreements between our two governments. We would, of course, first have to discuss with the Soviets the feasibility of any expanded program. Also, we would not want to commit ourselves to joint undertakings which might have changing relevance to the interests of our space program over the next several years. The American scientific community has not lost interest in cooperating with its Soviet counterparts in space research. Both governments continued active support of cooperation as recently as December 1983 when a joint biosatellite mission was undertaken. This type of research -- in space biology and medicine -- is an example of the arenas available for joint endeavors.

Naturally, any cooperative project should be scientifically sound and technically valid, should draw on unique Soviet capabilities in this area, and should be

carefully designed to avoid inappropriate technology transfer in order to meet our objective of equality, mutual benefit and reciprocity in our S&T interactions. Thus, the contributions each side is to make to a cooperative program must be carefully evaluated and kept in balance and the work must be carefully monitored to ensure that each side is keeping its commitment scrupulously. The closed nature of Soviet society, to which we seek access through cooperative activities, is asymetrical when compared with our open society, and can produce problems for us in bilateral undertakings. We have to guard against inequality of benefit.

From the Department's point of view, nothing is more worthy of our attention than finding ways to establish better communication with the people and the Government of the Soviet Union. We believe that cooperation in outer space could offer some unique opportunities if structured along the lines I have just described. We also believe that we have a very sound, and mutually beneficial proposal on a space rescue mission before the Soviet Union for its consideration - and we remain hopeful that they will eventually see the merit in that proposal.

This does not mean that we have forgotten Afghanistan or other actions by the Soviet Union which have led to the downgrading of bilateral cooperation between our two

countries. We will continue to demonstrate our deep opposition to and concern over such actions. At the same time, both we and the Soviet Union have a stake in placing our bilateral relationships on a sounder footing. Through the various proposals noted in the President's June 27th statement, we have again demonstrated the willingness of the United States to establish a better relationship with the Soviet Union. In the Department of State's judgment the balanced, step-by-step approach outlined in that statement is the approach most likely to produce the meaningful results we all desire.

Senator MATHIAS. Thank you.
Mr. Morrison.

STATEMENT OF JAMES R. MORRISON, DEPUTY ASSISTANT ADMINISTRATOR, INTERNATIONAL AFFAIRS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. MORRISON. Thank you, Mr. Chairman. It is a great pleasure to be here. This is not a committee before which NASA customarily has described its activities, so even though I am submitting a statement for the record, I would like to expand upon a number of points.

In a broad sense, NASA conducts its international cooperative programs in accordance with the NASA Space Act, which states that one of the principal goals of the U.S. civil space program is to cooperate with other nations in the peaceful uses of space. This fundamental policy has been reaffirmed by every administration and Congress since the act became law in 1958. Most recently, President Reagan highlighted this commitment to international cooperation in his State of the Union Address this past January, with specific reference to the space station program. He made a commitment that a space station in the early 1990's would be the next major goal of the United States in space and he coupled that with an invitation to all of our allies and friends to participate with us in that development, a major international initiative in space. In carrying out this overall policy of cooperation, NASA has entered into carefully constructed efforts with many nations, including the Soviet Union, to share the costs and benefits of selected space research and development efforts. To quantify that a bit, we have used the short phrase that in the 26 years of NASA's existence, we have concluded over 1,000 agreements with over 100 countries for space cooperation.

With some elementary mathematics, that boils down to about 40 international projects a year of one kind or another. Most of those, of course, are minor in that they involve the analysis by a foreign scientist of some of our data, or the flight of a foreign experiment

on a sounding rocket or a balloon, or things of that nature. But in addition, they do involve many major projects, the most recent of which the spacelab program which flew late last year, and that was a $1 billion effort on the part of our European colleagues. And the spacelab is a part of our space transportation system.

Turning to cooperation——

Senator MATHIAS. Mr. Morrison, I hate to interrupt you, but all of the bellringing you just heard indicates a vote on the Senate floor. I think we had better take a very brief recess. It will only take about 7 minutes for us to get there and back.

If we had some of your own vehicles, we could do it faster.

Mr. MORRISON. You might get there faster, but you might have trouble stopping. [Laughter.]

Senator MATHIAS. We will take about a 7-minute recess for the rollcall.

[Recess.]

Senator MATHIAS. Mr. Morrison, we cut you off in midstream.

Mr. MORRISON. Thank you, Senator Mathias.

I had just finished a brief overview of the breadth of the NASA international programs. I was turning to the history of cooperation between the Soviets and ourselves in space.

I just wanted to touch on the fact that there are essentially three different periods in which there have been agreement. One was in the early 1960's, the Kennedy-Khruschchev agreement in 1962, I believe. The second was the Nixon-Kosygin agreement of 1972, and the third was the renewal of that in 1977 to which we now refer as the Vance-Gromyko agreement. It was subsequent to that, that I think as Mr. Horner indicated, relations between the two countries started to go downhill, and that did have an effect on the space cooperation. Even though that effect took place, I would like to indicate that cooperation has not gone to zero. There is still some residual activity and I would like to take a moment to sketch that.

In space biology and medicine, detailed exchanges of biomedical data for manned missions have taken place since the early 1970's. Such information has proved valuable in assessing the short- and long-term effects of weightlessness on humans. Biomedical exchanges have also resulted in development of measures which have improved crew health during manned space flight.

In unmanned flight, the United States has participated in four Soviet biosatellite missions in 1975, 1977, 1979, and 1983. Numerous plant and animal experiments of ours have flown on each of these missions, and the most recent Soviet biosatellite mission which was conducted last December, the United States carried out primate and rat experiments during the 5-day flight. U.S. investigators have received the raw flight data from the Soviets since that time, and analyses are continuing at present.

In another area, joint U.S./U.S.S.R. Venus studies also have been undertaken in the areas of atmospheric composition, electric discharges, surface structure, and solar wind interactions. In addition, maps of the Venusian surface obtained by the 1978 U.S. Pioneer-Venus mission and U.S. technical cooperation assisted the Soviets in selecting landing sites of high scientific interest for their 1982 Venera 13 and 14 lander missions. In fact, I believe Dr. Masursky, who was here earlier, was very heavily involved in that activity.

This latter example clearly illustrates the enhanced scientific return that is possible when two countries with complementary programs agree to share information in order to produce mutually beneficial results. There are other examples that I am submitting for the record but I will, in the sake and interest of time, skip over them.

In evaluating this cooperation, it seems clear that there have been worthwhile scientific benefits to the United States over the years from undertaking space cooperation with the Soviet Union. It is partially with this in mind that, as President Reagan has announced, the administration recently proposed to the Soviet Union that a joint simulated space rescue mission be undertaken. It remains to be seen whether this will become a reality.

Finally, from NASA's technical perspective, there are some lessons that can be drawn from this cooperative experience. Throughout, the United States has sought to identify science applications and development projects which contribute to U.S. space objectives and utilize complementary Soviet space capabilities without incurring U.S. technology loss. We believe that the record shows that this can be done successfully.

Further, as the Administrator of NASA, Mr. Beggs, has said in a recent interview with U.S. News & World Report, and I quote: "In areas where a specific project is for the benefit of both countries, and where we can agree to do it, we are prepared to collaborate, to exchange data, and stay in contact with their space planners."

In evaluating such potential cooperation for the future, a number of guidelines are suggested. The projects should be scientifically justified, technically feasible, conducive to safeguards against technology transfer, and have at least comparable benefit to cost ratios as alternative projects on which the money could be spent. Obviously, guidelines such as these will be applied in a political context because of the high public visibility of this type of cooperation. Nevertheless, there should be an appreciation that if a major project should be interrupted while in progress, it is likely that the human and dollar resources would have been utilized better in other space endeavors. In other words, once undertaken, there are good reasons why a project should be allowed to proceed to completion, barring some major disruption in relations between the two countries.

In closing, I wish to assure you that NASA is pleased to be able to bring an additional dimension, the space dimension, to support American foreign policy objectives wherever possible.

Thank you, Mr. Chairman.

[Mr. Morrison's prepared statement follows:]

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Statement of

James R. Morrison
Deputy Director
International Affairs Division

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the
Committee on Foreign Relations
United States Senate

Mr. Chairman and Distinguished Members of the Committee:

It is a pleasure to be here today to testify on United States - Soviet space cooperation from NASA's research and development perspective.

In a broad sense, NASA conducts its international cooperative programs in accordance with the National Aeronautics and Space Act, which states that one of the principal goals of the US civil space program is to cooperate with other nations in the peaceful uses of space. This fundamental policy has been reaffirmed by every Administration and Congress since the Act became law in 1958. Most recently, President Reagan highlighted this US commitment to international cooperation in his State of the Union address this past January with specific reference to the Space Station program. In carrying out this policy, NASA has entered into carefully structured efforts with many nations, including the Soviet Union, to share the costs and benefits of selected space research and development efforts.

In the 27 years of the space era, there have been three separate periods of negotiation and agreement between the US and the USSR on space cooperation. The first was in the early 1960's, when President Kennedy entered into a dialogue with Soviet Premier Khrushchev which ultimately led to joint projects in telecommunications and geomagnetic mapping utilizing early satellites of both sides. In addition, NASA and the Soviet Academy of Sciences established a 24-hour communications link in 1962 for the exchange of satellite meteorological data in real-time -- the so-called "cold line"

between Washington and Moscow. These preliminary efforts demonstrated the potential usefulness of sharing scientific information in areas of mutual benefit with the Soviet Union, which at the time was the only other space-faring nation.

The second period of agreement was in the early 1970's, culminating in a summit meeting which took place in Moscow in 1972 between President Nixon and Soviet Premier Kosygin. At this meeting, an agreement on "Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes" was signed along with agreements for cooperation in other scientific and technical areas, such as in oceanography, artificial heart research, agriculture and energy. The US/USSR space agreement provided for the expansion of cooperation between the United States and Soviet Union in space science and applications as envisioned in a 1971 NASA/Soviet Academy agreement, and endorsed the establishment of four Joint Working Groups to develop collaborative efforts in the fields of space meteorology; study of the natural environment; exploration of near-Earth space, the Moon and planets; and space biology and medicine. Moreover, the 1972 Space Agreement provided endorsement of initial NASA/Soviet Academy efforts to examine the technical feasibility of developing compatible rendezvous and docking systems. On this basis, the two countries embarked on the first important joint development effort, which in time

became known as the Apollo-Soyuz Test Project (ASTP). The primary objective of ASTP was to demonstrate the feasibility of a joint docking system that would make possible future cooperation in manned spaceflight between the US and Soviet Union. In July 1975, the US Apollo and Soviet Soyuz spacecraft docked successfully for two days, during which time crews were exchanged and five joint experiments were conducted.

In 1977, with the accomplishments of previous collaborative efforts in evidence, the US and USSR renewed the 1972 agreement. The renewal, signed by Secretary of State Vance and Soviet Foreign Minister Gromyko, endorsed the continuation of US/USSR cooperative activities in space science and applications through the four Joint Working Groups established earlier, and provided for a new joint project to commence in the area of satellite-aided search and rescue. Drawing upon the technical success of ASTP, the 1977 agreement also called upon both countries to begin follow-on studies of compatible rendezvous and docking systems, and in particular, it endorsed a separate, just-concluded NASA/Soviet Academy agreement to study the feasibility of effecting dockings between the US Space Shuttle (still under development at that time) and the USSR Salyut space station (already in existence). This bilateral relationship in the space area began to languish shortly thereafter, along with a progressive deterioration in the overall political relationship with Moscow. This deterioration became increasingly evident beginning in 1980 as

a result of the Soviet invasion of Afghanistan. High-level joint space meetings were deferred, no US initiatives for scientific cooperation were proposed, and following the imposition of martial law in Poland in late 1981, the Government-level space agreement was allowed to lapse in 1982. That status continues at present.

It may be of interest to the Committee to take a moment and look at a number of areas of cooperation in a little more detail. In the near-Earth space and planetary area, lunar samples were exchanged in 1976 from the US Apollo and Soviet lunar retrieval missions, and analyses are continuing. In 1978, the Joint American-Soviet Particle Intercalibration Project (JASPIC) was conducted to establish the validity of US and Soviet energetic particle instruments in the direct measurement of electrons and protons in the Earth's ionosphere. This project involved near-simultaneous launchings of payloads on US and USSR sounding rockets from Wallops Island, Virginia for the US and from a Soviet research ship just offshore from Wallops.

Since 1979, joint US/USSR Venus studies also have been undertaken in the areas of atmospheric composition, electrical discharges, surface structure and solar wind interactions. In addition, maps of the Venusian surface obtained by the 1978 US

Pioneer-Venus mission and US technical collaboration assisted the Soviets in selecting landing sites of high scientific interest for their 1982 Venera 13 and 14 lander missions. This latter example clearly illustrates the enhanced scientific return that is possible when two countries with complementary programs agree to share information in order to produce mutually beneficial results.

In space biology and medicine, detailed exchanges of biomedical data from manned missions have taken place since the early 1970's. Such information has proved valuable in assessing the short and long-term effects of weightlessness on humans. Biomedical exchanges have also resulted in development of measures which have improved crew health during manned spaceflight. In unmanned flight, the US has participated in four Soviet biosatellite missions - in 1975, 1977, 1979 and 1983. Numerous US plant and animal experiments have flown on each of these missions. In the most recent Soviet biosatellite mission conducted last December (Cosmos 1514), the US carried out primate and rat experiments during the five-day flight. US investigators have received the raw flight data from the Soviets since that time, and analyses are continuing.

Another area deserving mention is our current multilateral humanitarian project involving satellite-aided search and

rescue. In cooperation with the Canadians and French, the US since 1979 has been engaged with the Soviets in the COSPAS-SARSAT experimental program to demonstrate the use of satellites to assist maritime and aeronautical search and rescue activities. Three Soviet satellites and one US satellite have already been launched and have helped save over 200 human lives.

In evaluating this cooperation, it seems clear that there have been worthwhile scientific benefits to the US over the years from undertaking space cooperation with the Soviet Union. It is partially with this in mind, that, as President Reagan has announced, the Administration recently proposed to the Soviet Union that a joint simulated space rescue mission be undertaken. It remains to be seen whether this will become a reality.

Finally, from NASA's perspective, there are some lessons that can be drawn from this cooperative experience. Throughout, the US has sought to identify science, applications and development projects which contribute to US space objectives and utilize complementary Soviet space capabilities without incurring US technology loss. We believe that the record shows that this can be done successfully.

Further, as Mr. Beggs has said in a recent interview with US News and World Report, "In areas where a specific project is for the benefit of both countries, and where we can agree to do it, we're prepared to collaborate, to exchange data and stay in contact with their space planners."

In evaluating such potential cooperation for the future, a number of guidelines are suggested. The projects should be scientifically justified, technically feasible, conducive to safeguards against technology transfer, and have at least comparable benefit-to-cost ratios as alternative projects on which the money could be spent. Obviously, guidelines such as these will be applied in a political context, because of the high public visibility of this type of cooperation. Nevertheless, there should be an appreciation that if a major project should be interrupted while in progress, it is likely that the human and dollar resources would have been utilized better in other space endeavors, i.e., once undertaken, there are good reasons why a project should be allowed to proceed to completion, barring some major disruption in relations between the two countries.

In closing, I wish to assure you that NASA is pleased to be able to bring an additional dimension, the space dimension, to support American foreign policy objectives whenever possible. Thank you for the opportunity to testify before this prestigious Committee today.

Senator MATHIAS. Thank you, Mr. Morrison.

Mr. Horner, I take your point that cooperation in space has not historically proved to be an alternative to an arms race in space. And it is true that on page 3 of the resolution at lines 10 and 11, it is specifically provided to explore opportunities for cooperative East-West ventures in space as an alternative to an arms race in space.

My question is, then, Do you see any virtue to cooperation in space for its own value, if not as an alternative to the arms race?

Mr. HORNER. We have always approached international cooperation in science from two perspectives. The first is that there are many kinds of international cooperation which benefit the United States, which improve our own scientific capability by giving us an opportunity to learn things that we don't know. In that sense we strengthen our own scientific prowess by cooperation with foreign countries, and that in itself is a very good thing. And we try to promote that.

At the same time, we also gain various different kinds of political benefits from it. As a general proposition, we have always believed that international cooperation in all of these areas is a good thing, both scientifically and politically.

Senator MATHIAS. Perhaps I should ask you whether the Department of State shares the NASA estimate of the low risk of technology transfer as described by Mr. Morrison.

Mr. HORNER. We have in the Government a rather elaborate mechanism for assessing the technological transfer risk of any project. I think, as Mr. Morrison said, projects can be designed with sufficient care so that adverse technology leakage or harmful technology leakage is not inevitable.

Senator MATHIAS. You, too, mentioned the meeting that was held at the White House in June and the President's expression of interest in renewed cooperation with the Soviet Union including a joint space rescue exercise.

Just so the record does not become confused on this point, that is not the same as the SARSAT program which is the subject of the article in today's Washington Post.

Mr. HORNER. That is right. That is an entirely different thing. In my preliminary summary I may have said "search and rescue," but I should have said "simulated" rescue mission which is different from SARSAT.

Senator MATHIAS. Has the Department of State or NASA developed a position on the funding of the SARSAT program, or has that controversy not yet matured to the point that you have a position?

Mr. HORNER. In all of these science projects in which the Department of State is involved internationally, we rely on the various agencies and departments of the Federal Government which have actual scientific and technical capability. They, in turn participate in international programs in ways which allow them to fulfill their own domestic mission. They do not participate in international programs merely to participate in them, but rather, as Mr. Morrison said, because they can identify forms of international cooperation which are beneficial.

Now, the question that has arisen here as to how many weather satellites the Commerce Department ought to have and at what rate they ought to be launched and how much they ought to cost has to be a political and budgetary decision which reflects the priorities within domestic programs.

So far as the international aspect of it is concerned, we think it's a very desirable thing to have a domestic program, which allows this kind of international adjunct. But obviously, we aren't in a position to say to the Commerce Department that it ought to have a certain number of satellites.

Senator MATHIAS. So you are for it in principle.

Mr. HORNER. Well, I think we are for it more than in principle. The problem here is whether or not it is appropriate for the State Department to urge the purchase of a particular satellite or the launching of satellites in a particular way because of the international political benefits that could arise.

Now, in the spirit of full disclosure, I must point out that my wife, Constance Horner, happens to be the Associate Director of OMB in whose area this particular problem falls, so I have a unique perspective.

Senator MATHIAS. I don't want to stimulate any domestic discord. [Laughter.]

Mr. HORNER. I have developed a unique perspective on this particular problem and the ongoing discussion among those parts of our Government that are concerned with it.

Senator MATHIAS. Well, I hope that over your morning coffee, you will suggest to her that this may be more than a matter of some vague international good will.

Mr. HORNER. I try to point out that we fly a lot, and that we are potential beneficiaries of this at any time.

Senator MATHIAS. I believe 247 lives have been saved.

Mr. HORNER. Exactly.

Senator MATHIAS. All as a result of this system. This suggests a very practical and humanitarian aspect as well as some indefinable political benefits that may result from further cooperation.

Well, as I say, I don't want to promote domestic discord in your household, but I hope you will carry that message forward.

Mr. HORNER. I shall.

Senator MATHIAS. I was present at the White House in June when the President made his statement on United States-Soviet exchanges, and he did express, I think strongly and eloquently, a desire for increased cooperation with the Soviet Union. But you have testified here this morning that you think it is premature to talk about renewal of the agreement.

Perhaps you could expand a little for us on what are apparently two contradictory points of view.

Mr. HORNER. I don't think so. In general it is sounder practice to begin with the discrete and simpler possibilities first before defining in a general agreement a more elaborate and more complex agenda. The simulated rescue mission proposal that we have made, for example, is an interesting place to start.

If we could get a better feeling for what the Soviet Government thinks about that, it might provide a better basis for a more general discussion. As Mr. Morrison said, we are constantly trying to

identify new areas in our own space program, and it just seems more natural to try the simpler thing first before going on to the more complicated and difficult thing.

Senator MATHIAS. One might analogize the joint space rescue exercise with the ping-pong game as a place to begin the improvement of relationships.

Mr. HORNER. It is considerably more expensive, I think, and probably a bit more challenging.

Senator MATHIAS. If it is equally as effective as ping-pong was for the United States and the People's Republic of China, why it may be worth what it costs.

Mr. HORNER. If my memory serves, it was Premier Chou who invited the U.S. table tennis team to come, and it did. I think we have the reverse of that situation now; we have invited some people to come, and we will wait to see what they do.

Senator MATHIAS. Mr. Morrison, you have described some of the ongoing United States-Soviet exchanges. What can you tell us about the kind of reaction you get when a new proposal is made to the Soviet Union for some exchange?

Mr. MORRISON. Mr. Chairman, we are not making, other than the simulated rescue mission that Mr. Horner referred to, any new proposals at this time. At the time that it was decided to allow the overall space agreement to lapse in 1982, the specific injunction was that we could complete the activities that had already begun under that agreement, but we were not to take any new initiatives. And we have not done so.

I think what you have heard Mr. Horner describe is an attempt on the part of the administration to do that at this time and identify whether there is interest on the Soviet part at the political level to open this back up again. And we are waiting.

Senator MATHIAS. So the examples of exchanges that you have given and that you have included in your sta'ement are really the fruits of previous efforts?

Mr. MORRISON. That is correct.

Senator MATHIAS. They represent the kind of momentum that was developed but which has not fully been exhausted.

Mr. MORRISON. That is correct.

Senator MATHIAS. But if no new suggestions are being made or, to put the shoe on the other foot, if the Soviet Union is not responding to the single new suggestion that has been made, then when this momentum has finally been spent, these exchanges will dry up completely.

Mr. MORRISON. In the sense that the formal exchanges will, yes, that is correct. I think you heard this morning that some of our scientist friends are relatively ingenious as to how to keep the scientist-to-scientist contact going in the absence of agency-level or government-level contact. But in a formal sense of NASA to the Soviet Academy activity, your assessment is correct.

Senator MATHIAS. And what will that mean in the scientific world? What will that mean to NASA?

Mr. MORRISON. I think you have to look at this in a couple of different planes. Speaking from the technical standpoint from NASA's own perspective, not a political perspective, there are areas of activity in which the Soviets are engaged which are mean-

ingful to us, some of which were illuminated this morning—in the space biology and medicine areas certainly; in the coordination of future activity as both countries work on its programs aimed toward Venus and Mars.

Technically, it makes sense to talk. But, NASA is realistic enough, I believe, to realize that for better or for worse, there is linkage between the politics of the two nations and the technical aspects in the space area. And with politics being primary between the Soviet Union and ourself, we recognize that some of these things have to be deferred until the primary relationship is established.

I might take a moment to analogize. There have been a number of analogies this morning. I will add my own. To a certain extent it seems to me we are talking about what I used to hear in my much younger days, in my youth, that it was possible that if a marriage were going bad, that if the family had children it would improve the marriage. That can be very hard on the children, and there is no substitute for a good primary relationship. I think that analogy is not without meaning in that area.

Senator MATHIAS. You have said that many of these questions have to be subordinated to the political decisions that are ultimately made. I understand what you say.

This committee will try to comprehend the details. We will have to look at the cost-benefit ratios, for example, in the SARSAT program. We will have to look at the risks of technology transfer, and we will have to look at all these related matters. But I think you are right, that ultimately this becomes a political question, and I use political in the sense of high policy, because anything which affects the ultimate relationship of the two super powers which command such enormous destructive force is the highest policy of all, and that must be controlling.

I was not being facetious when I suggested that any small initiative in this area—and I am glad we have taken one in the President's proposal of the joint space rescue exercise— that any small initiative might bear fruit, as Chou En-lai's invitation to a ping-pong game did so conspicuously a decade ago.

There is an Office of Technology Assessment Report on space arms control that suggests how high the political stakes really are, how dangerous the policy issue is in this whole subject. OTA says "future United States and U.S.S.R. activities in space hold great potential for generating uncertainty and misunderstanding regarding the countries' respective intentions."

Would you share that concern and would you agree that, on the other side of the page, a higher level of cooperation might reduce that uncertainty and that chance of misunderstanding?

Mr. HORNER. It is difficult, I think, to respond to a somewhat arch formulation like that of the OTA in the absence of sort of more concrete references.

Senator MATHIAS. Perhaps I was unfair to OTA, but I quoted you only very briefly from the report.

Mr. HORNER. It is hard to analyze the significance of what different nations are doing in space or anyplace else. When the Soviets, for example, undertook to test and to deploy an antisatellite

system, there were many implications, I suppose, that one could draw from that.

But once again, the general problem we face is how to do concrete things in individual areas which could have the effect of improving the political climate and promoting and increasing understanding between countries.

Our experience has been, unfortunately, that it is very hard to establish a one-to-one correspondence or even a fraction-to-one correspondence between the enhancement of activities in science cooperation on the one hand and the real state of political relations on the other hand.

For example, to what degree would a renewed space cooperation program between ourselves and the Soviets affect Soviet research and development of technologies for space weapons. How would it influence the evolution of their antisatellite system? In all of those things, there is a very difficult connection to establish. It could easily work in reverse, you see.

Senator MATHIAS. But that isn't my question. I really conceded at the outset of my questions to you that your point that space cooperation has not been an alternative to military activity in space is well taken. My point is, if we cooperate, will we have a better understanding of what is happening? That we conceivably would be more concerned or less concerned, but will we definitely have a better understanding?

Mr. HORNER. It is certainly not impossible that we could. And the prospect that we might is one of the things which stimulates the interest of the U.S. Government in this kind of activity.

Obviously, one wouldn't propose this kind of activity if one felt that it was futile. So I suppose, beneath it all, is the notion that there are benefits to be derived from it.

Senator MATHIAS. Did you want to comment on that, Mr. Morrison?

Mr. MORRISON. No, I don't think so. The two activities on the space defense initiative side and the civil side basically involve different casts of characters—here certainly, and I would suspect in the Soviet Union as well. So the degree to which, by energizing one communications link, it would go over into another one, I agree with Mr. Horner; it may there, but it is very hard to speculate on that at this time.

Senator MATHIAS. I regret that the activities on the floor have delayed other members of the committee from returning. There is another vote imminent, which is causing them to have been delayed.

I am wondering if I could ask a favor of you. If there are questions that they need to propound to you, which we wish to get into the record, could we submit questions in writing to you and get your responses very promptly?

[Mr. Morrison and Mr. Horner nod affirmatively.]

Senator MATHIAS. The reason Senator Pell amended his request that the record be kept open only until this evening is so that this matter might be presented to the full committee at its next session. So if you would agree to that, I would be very grateful to you.

Thank you very much.

We have made some reference to two OTA reports, and I think that it might be useful to include as a part of the record the summary of that report on "Future United States-Soviet Space Cooperation."

[The OTA report follows:]

FUTURE U.S.-SOVIET SPACE COOPERATION

September 13, 1984

Proceedings of workshop held at OTA on May 8, 1984

Compiled by the staff of the Program on Science, Transportation, and Innovation

Office of Technology Assessment
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Washington, D.C. 20510

This OTA Staff Paper has neither been reviewed nor approved
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39-395 O-84--7

Since the expiration of the U.S.-Soviet space cooperation agreement, many questions have been raised about its real value to the U.S. space program and to U.S. interests generally. The Office of Technology Assessment (OTA) is conducting a study of the possibility of renewing the intergovernmental agreement, at the request of Senators Mathias, Pell and Matsunaga. As a first step in this study, OTA organized a workshop of leading American space scientists to assess the scientific advantages and disadvantages of U.S.-Soviet cooperation in space science. Given the context of increasing international scientific activity in space — and increasing costs of space missions, whether primarily scientific or not — participants in the OTA workshop were asked to evaluate the scientific exchanges that occurred under the agreement, to assess current Soviet capabilities in space science, and to estimate the prospects for future beneficial scientific cooperation in space. This is a summary of the workshop proceedings.

EVALUATION OF THE PREVIOUS AGREEMENT

The two primary areas of scientific cooperation under the agreement* were in (1) Space Biology and Medicine and (2) Near-Earth Space, the Moon, and the Planets. Of these, the life sciences area is generally recognized as having been the more substantive and successful in terms of the cooperative exchanges actually implemented.

In the space life sciences, three areas were particularly fruitful. First was the exchange of flight experimental data regarding human response to spaceflight conditions. In view of the emphasis on extended manned spaceflight in the Soviet program, of greatest value here were Soviet data on the effects of long-duration flight on bone loss

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* The "Agreement Between the United States of America and the Union of Soviet Socialist Republics Concerning Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes," signed in May 1972 and renamed in May 1977.

and cardiovascular deconditioning — problems that continue to be of significant concern for manned spaceflight. The second area of cooperation consisted of joint ground-based simulations of spaceflight conditions (an example would be long-term bed rest studies). Finally, Soviet Cosmos-series biosatellites provided U.S. investigators with a number of opportunities to fly experiments designed to investigate basic biological processes in space, and to exchange information on a range of problems in space biology.

Scientists involved in these exchanges believe that the overall success of the collaborations in life sciences can be attributed to several factors:

- a focus on well-defined and specific scientific objectives;
- the selection of areas of complementary capability, providing strong motivations to cooperate;
- the fact that required instrumentation was not generally of a type involving concerns of technology transfer;
- an institutional organization that granted officials on both sides the autonomy to decide on the implementation of plans; and
- the development of mutual confidence, knowledge, and goals among working groups over a long period of cooperation.

In the planetary category, the strongest areas of cooperation were in lunar studies, the exploration of Venus, and solar-terrestrial physics. The exchange of lunar samples and cartographic data provided both sides with a range of information unobtainable by either program alone. Although the Soviets shared few significant data from their Mars missions in the early 1970s, the cooperation in the late '70s and early '80s between Soviet scientists in the Venera program and U.S. investigators in the Pioneer Venus program was substantial, extending to the use of Pioneer Venus data to select Venera landing sites and to attempts to intercalibrate instruments. In the solar-terrestrial area, exchanges of solar wind data obtained by Soviet Prognoz and U.S. International Sun-Earth Explorer (ISEE) spacecraft have been valuable because of differing spacecraft design characteris-

tics, while U.S. magnetospheric plasma physics research in space has benefited from cooperation between the two countries in controlled thermonuclear research. Overall, there has been an evolution toward greater openness in the Soviet planetary program over the past decade, though in general many of the data shared by the Soviets are given to relatively few individual U.S. scientists and do not easily make their way into the world scientific literature.

Finally, there has been a significant amount of cooperation in astrophysics experiments utilizing detectors mounted on a variety of spacecraft, including Venera and Pioneer Venus, Helios, Prognoz, and ISEE. The objective of these experiments was the precise location of gamma-ray bursts by means of simultaneous observations from widely separated spacecraft, with cooperative analysis of resulting data.

Most of the scientists involved in these exchanges believe that the cooperation was quite fruitful. Particularly with regard to Venus, the United States gained at least as much information as it provided. However, the interaction in the planetary and solar-terrestrial areas was not as consistently smooth as in the life sciences. There were significant difficulties in acquiring information on mission plans, and in obtaining accurate and complete scientific data. These problems varied in severity through time and across different fields. But there is a general opinion among the U.S. scientists involved that the situation was improving noticeably, with regard to both openness and data quality, when the intergovernmental agreement expired. At that time, U.S. scientists were for the first time being taken into Soviet laboratories and shown instruments, performance data, etc.

In an overall sense, then, U.S.-Soviet cooperation in space science under the agreement appears to have been of positive scientific value for the United States. But the question of costs was also discussed at length during the OTA workshop — costs primarily in the form of technology transfer. Workshop participants expressed the belief that, because of the rigorous reporting requirements of our own scientific community, normal

U.S. scientific publications are sufficiently detailed, in terms of both instrument descriptions and experiment results, for Soviet scientists to base their plans upon — even without explicit cooperative agreements. At most, U.S. experimenters involved in cooperation with the Soviet Union are likely to transmit information to their Soviet counterparts only six months in advance of its appearance in the open literature.*

The question of reciprocity in data exchange was also addressed. Participants had found that, because U.S. scientists generally do not read Soviet journals, and because information appearing therein may be incomplete, personal contact was the most effective way to acquire Soviet scientific information. Although personal exchange is not the most consistent or reliable medium, U.S. scientists are generally satisfied that it provides an adequate basis for reciprocity in data exchange. Since, in any case, Soviet scientists obtain U.S. results through the open literature, workshop participants agreed that any reliable Soviet data acquired, even if only through personal contact, are better than none. Reliance on such communications may simply be a matter of making the best of an imperfect situation.

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* This reasoning is also applicable to the special case in which instruments are provided. Data regarding interface requirements and so on — often alluded to in discussions of technology transfer — are also soon available in open publications. However, under the previous agreement the majority of instruments supplied for Soviet missions were bioinstrumentation in the life sciences; there is general agreement that transfer of this equipment posed no risks to national security.

CURRENT CLIMATE AND OUTLOOK FOR FUTURE COOPERATION

In discussing U.S.-Soviet cooperative activities since the expiration of the space cooperation agreement, and in assessing current trends in the strength and direction of the Soviet space program, workshop participants arrived at four major points of consensus regarding prospects for future cooperation.

1. ***Important scientific interchanges continue today, demonstrating the willingness of U.S. and Soviet scientists to cooperate. But these interactions are dwindling and their future is uncertain; few initiatives are being taken. Leading Soviet scientists consistently express a strong wish to cooperate further, but little can be done without a formal framework for cooperation. There are cases where the lack of a bilateral agreement has been a clear impediment to space science exchanges.***

A substantial amount of activity has been seen in the life sciences since the expiration of the agreement. A Cosmos biosatellite mission, flown in December 1983, carried a suite of U.S. biological experiments. In addition, CAT-scan bone data from Soviet manned missions continue to be received for analysis in the U.S. Both of these interchanges were planned under the previous agreement, but have been carried out despite its expiration. Recent months have also seen joint publication of the results of ground-based studies conducted prior to May 1982. However, NASA is still awaiting the results of biomedical studies conducted aboard a 211-day Salyut 7 mission, concluded in December 1982. Scientists in this field report that the quality of interchanges, personal as well as scientific, has not declined since the agreement expired; but the overall amount of activity is declining steadily as previous arrangements are concluded.

In the planetary area, leading Soviet scientists recently made presentations, at several U.S. academic institutions, of radar data from Venera 15 and 16, both currently in orbit about Venus. U.S. and Soviet scientists also continue to exchange Pioneer Venus radar altimetry data and Venera gas chromotographic and mass spectrometric data. Recent collaborations in studies of solar wind interactions with Venus, Vega/Venera

landing site areas, and Venus lightning have involved exchange and subsequent interpretation of data. Certainly one of the most interesting activities in all of space science at present is the preparation for the Halley missions in 1986. The U.S.S.R. is taking a lead role in this multilateral mission. In conjunction with the Halley effort, a working group of the Interagency Consultative Group (IACG) is planning an extensive coordination of plasma experiments for comets.* U.S. and Soviet scientists are actively involved in joint planning, and Soviet investigators will be at Goddard when the U.S. International Comet Explorer (ICE) spacecraft flies by the comet Giacobini-Zinner. The ICE mission, using the redesignated ISEE 3 spacecraft, is an important step in support of planning for the Halley mission. According to the U.S. participants, their Soviet counterparts must overcome considerable obstacles at both the U.S. and Soviet ends in order to attend, but continue to persevere.

Soviet scientists continue to attend international scientific meetings held in the United States and elsewhere, and leading scientists such as Roald Sagdeeyev and Valery Barsukov continue to meet with their American scientific counterparts. (Soviet scientists at the working level, however, attend such meetings infrequently.) Reports of these meetings consistently stress that Soviet as well as American scientists have expressed a desire for renewed cooperation, and relate the frustration felt on the Soviet side regarding the lack of a framework for cooperation. In one case, Brown University and the Vernadsky Institute had reached initial agreement that two Soviet scientists would visit Brown for two months, but the ruling body of the Soviet Academy cancelled the visit on grounds that the institution-to-institution agreement was being used to circumvent the lack of an intergovernmental agreement.

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* The IACG is an international working group whose members represent the space agencies (rather than the governments) of the United States (NASA), Europe (ESA), Japan (NASDA), and the Soviet Union (Intercosmos).

2. ***Soviet capabilities are increasing rapidly in many areas of space science. Scientific and technical versatility has improved; data are more reliable; and missions can be mounted more rapidly and with greater confidence.***

Workshop participants were unanimous in their opinion that Soviet capabilities in many areas of space science have increased greatly in recent years. Most impressive of all has been the evolution of the Venera program. Soviet landers have survived on the extremely hot Venus surface, in a highly corrosive atmosphere, for more than an hour while returning photographic data and performing soil sample analysis. With the current Venera 15/16 mission, the Soviet program has demonstrated a host of advanced capabilities: synthetic aperture radar (SAR), digital processing, image processing and enhancement, and the achievement of a successful long-lived orbiter. This combination of technologies on a single mission — particularly SAR — represents a substantial advancement of Soviet planetary capabilities. Although the individual technologies employed on Venera orbiters are all well within current U.S. capabilities, it is nonetheless true that they will not all be employed together on a U.S. mission until 1988, with the Venus Radar Mapper (VRM) spacecraft. Moreover, a major upgrading of the basic Venera spacecraft, comparable with plans for the U.S. Mariner Mark II, is currently being planned.

The upcoming Halley mission provides a clear demonstration of the improved Soviet scientific capability. In effect, the Soviet Vega spacecraft is the "flagship" of the flotilla that is going to Halley; according to one U.S. scientist, it will probably be superior to the European package, and certainly superior to the Japanese Planet-A. The Soviets have led in providing guidelines for the protection of all participating spacecraft from cometary dust — and have, in the process, been quite free in the provision of data. Additionally, it is Vega's precise pointing capability that will help to guide the European Giotto spacecraft as it approaches the comet. Beyond Vega's ample responsibilities with regard to Halley, it will carry two Venus landers and Venus atmospheric balloons; overall, it will be comparable to the U.S. Viking spacecraft in the complexity of its mission.

According to U.S. scientists in the field of plasma physics, over the past five years the Soviet Union has reached the international state of the art in earth magnetospheric physics, although the world scientific literature does not reflect this fact. However, spacecraft data links and data processing capability are said still to lag behind those of the U.S.

Soviet life sciences capabilities have not shown any correspondingly dramatic improvement, but technical virtuosity is not as great a factor here. The continued success in conducting long-term manned operations in orbit — in itself a dramatic achievement — does demonstrate, however, that Soviet approaches to nutrition, conditioning, psychological support, and other measures to counteract deleterious effects of the space environment on cosmonauts are achieving their objectives.

Improvements in Soviet space science capability appear to have been accompanied by improvements in the quality of data and by a willingness to communicate those data to American scientists in adequate detail for comparison and analysis.

One significant difference between space science in the United States and the Soviet Union is that Soviet scientists are often able to repeat their experiments. The continuity in the Soviet program thus provides the ability to respond to previous data and to confirm results — both important advantages from a scientific standpoint.

Another indicator of strength in the Soviet space science program generally is the speed with which missions can be planned and carried out. One U.S. planetary scientist recalled that, when the U.S. cancelled the planned Venus Orbiting Imaging Radar (VOIR) mission (and before the mission was reconfigured into the currently planned VRM), the Soviets leaped into the breach with a very similar mission. Venera 15/16 flew 18 months later. Although the quick Soviet response may not be the norm, it is an accomplishment that the United States would be hard-pressed to match.

3. ***As Soviet capabilities have increased, their space program has become more open. The expansion of Soviet cooperative activities with other countries in space further improves their capabilities, and presents the possibility that the U.S.S.R. will become a leader not only in space science but also in international cooperative ventures in space.***

The general consensus among the space scientists at this workshop was that, the stronger Soviet capabilities in space science become, the more the Soviets are willing to provide in the way of detailed information about their plans and results. While there was some disagreement over the extent of improvement in this area, it appears that the general trend is toward a greater openness.

Whereas the quality of data provided by Soviet scientists in the past was often not adequate to enable their U.S. counterparts to determine its validity, what individual U.S. researchers are now receiving is described as valid scientific information. This change seems to reflect some lowering of artificial secrecy barriers, which is attributed in part to increased confidence on the part of Soviet scientists, and in part to the positive experience of cooperation.* For example, Soviet scientists are now willing to admit failures of missions as well as instruments — a major change from past practice. This change in attitude has not yet been expressed in official policy, but it is noticeable on an individual level — which may also account for the variability in the experience of individual U.S. scientists in this regard. It must be said, though, that the practice of data sharing among individuals, however valuable in itself, falls far short of the standard scientific practice of publication of research results in the open literature.

Even in the current political climate of mistrust, Soviet researchers have readily presented Venera 15/16 radar data, providing them even in advance of official release. The Halley collaboration described earlier is a further instance of Soviet openness. Halley also demonstrates another aspect of change in the Soviet space science program:

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* The latter belief was expressed by Dr. Sagdeeyev in a meeting in Washington in May 1984.

Since about 1976, the U.S.S.R. has endeavored to improve its space science effort by incorporating international participants (beyond the somewhat pro forma inclusion of East-bloc guest cosmonauts in Salyut missions). Numerous joint missions and hosted experiments have been flown with France and West Germany, and more are planned. (The Vega Halley mission includes a number of European experiments.) The predominant areas of cooperation have been astronomy and astrophysics — fields in which the Soviet Union has not been strong. This trend should be considered carefully by the United States, for it introduces the notion of international cooperation in space science as a competitive tool.

For the first 20 years of the space age, the U.S. was preeminent as the "flag-flyer" for other nations — with space science as the most common domain of cooperation. The Soviet Union now appears to be making a determined effort to preempt that role. U.S. scientists have been hearing that the Soviets are planning an unmanned Mars mission for the late 1980s which will be heavily international in character. There are also plans for an "International Venus Mission" following Halley, in 1991. Without a comparable U.S. cooperative effort in the meantime, these missions could well establish the Soviet Union as the world leader in the international aspects of space science. The Soviet commitment to long-term space science plans and programs is an undeniable factor in its attractiveness to other nations as a cooperative partner.

For the United States, the significance of these trends in Soviet capabilities and practices is that it will have to decide whether to compete or to cooperate. And, in the view of the workshop participants, if the U.S. does intend to cooperate we are in a better bargaining position now than we are likely to be in the future, when Soviet capabilities in space science will have increased further.

4. ***Increased Soviet mission capabilities mean that a fundamental change has occurred in the relative balance between the U.S. and Soviet space programs. In certain scientific areas, we may now have more to gain from the Soviets than they from us. In the future, technology transfer could well become a more realistic Soviet concern, as the direction of potential transfer becomes increasingly two-way.***

The traditional view of U.S.-Soviet scientific exchanges is that the Soviets can only gain and the United States can only lose. This belief has certainly applied to space cooperation between the two countries, and has been a powerful argument against it. Yet the greatly increased Soviet capability in space science must be recognized as having changed the situation. There is a strong agreement among U.S. scientists that, at least in certain aspects of planetary science (i.e., Venus and Halley's Comet), the United States has more to gain than to lose from such exchange. The planned Soviet Mars mission will strengthen this argument even further.

Because of differences in priorities and programs, the Soviet Union has provided American scientists with a wealth of data and information otherwise unobtainable. And some scientists have suggested that the Soviet Union may be more advanced in the development of certain types of technological hardware. Planetary landers are one example; the success of Venera landers in the harsh environment of Venus would be difficult to duplicate with current U.S. technology.

On the other side of the coin, in most areas of space science the issue of "technology transfer" to the U.S.S.R. is not clear-cut. For example, workshop participants disagreed as to whether technology transfer necessarily accompanies data exchange. Some expressed the view that "once you know the quality of the data, you already know a great deal about the instrument." The example of a pointing system was given, in which divulging the pointing accuracy would not only reveal U.S. capabilities of military significance, but would also set technical goals for the Soviets. Consequently, instruments on U.S. missions are sometimes built to embody less than the maximum available capability, so that subsequent publication of data will not compromise national security. In prac-

tice, however, civilian space science missions often cannot afford state-of-the-art technologies. Thus, capabilities are frequently limited by cost rather than by security concerns.

Flying instruments on foreign spacecraft raises similar technology transfer questions. Whether data needed for interfacing reveal too much about design parameters has been a recurrent question; but, as was mentioned earlier, workshop participants indicated that equivalent data can usually be gleaned from standard U.S. research reports. A converse point was also noted, namely, that the receiving party must reveal corresponding information about their spacecraft in order to permit integration. Closely related to this issue is the question of whether delivering an instrument to the Soviets for integration onto a spacecraft must involve a risk that they will dismantle the instrument. The opinion was expressed that, whether or not the practice occurs, there is no great risk associated with it: state-of-the-art technology is not always utilized to conduct space science, and there is some question as to what the Soviet Union may gain from this exercise in the first place. But the entire question of technology transfer remains controversial. Again, the key issue, as the workshop participants saw it, was that the Soviets could learn what capabilities the United States had developed or what capabilities in general were attainable, although not necessarily how the technologies could be developed.

The question of increased Soviet cooperative activity with other countries was also addressed from the standpoint of technology transfer. As in other areas of concern about technology transfer, U.S. policies must take into account the possibility of "foreign availability." Clearly, if technology transfer is a major consideration in the context of space science, then the flight of French infrared detectors and West German plasma probes (for example) is an important opportunity for the Soviet Union. However, the same uncertainties outlined above apply in these cases. Here also there is the question of whether the technology involved is actually state-of-the-art.

In short, an important point derived from the workshop discussions is that the issue of technology tranfer vis-a-vis the Soviet Union, at least in space science, is no longer as one-sided as it once was.

SCIENTIFIC BASIS FOR FUTURE COOPERATION

Workshop discussions resulted in a number of general observations and some specific recommendations regarding the scientific content and possible cooperative mechanisms to be employed in any future agreement with the Soviet Union for space cooperation.

A key point was that such a cooperative agreement must be based, for scientific as well as political reasons, on U.S. self-interest. The Soviet Union has enough to offer scientifically that cooperation for its own sake is no longer an adequate rationale for the United States. Any such cooperation must also be founded on a strong U.S. program in order to provide the necessary incentives to Soviet cooperativeness. In particular, areas of complementarity such as that represented by American analytical capability and Soviet lander capability provide strong incentives to cooperate.

There was considerable discussion of the actual mechanisms of cooperation employed under the previous agreement, and their relative merits. Participants agreed that the simplest levels of exchange — joint discussions, cooperative data analysis, and joint planning of separate missions — were the most workable. Hosted U.S. experiments on Soviet spacecraft (as well as the reverse) were also viewed as practicable, although official U.S. concerns about technology transfer have introduced considerable complexity into some of these interactions in the past. Participants agreed that the introduction of hardware into the exchange was invariably a complicating factor. The difficulty of working together reached its highest point in the case of full-scale joint missions, where both hardware and many layers of official participation were involved.

With these thoughts in mind, workshop participants attempted to identify new mechanisms of cooperation that might increase the range of workable exchanges. Based on successful past cooperation in planetary, solar-terrestrial, and astrophysics studies, it was suggested that to joint mission planning be added the concept of coordination and tracking of separate spacecraft. The advantage here would be to maximize scientific return while minimizing problems of hardware exchange and technology transfer. A second recommendation was to include the concept of U.S.-Soviet co-investigators among the types of cooperation.

Participants also addressed the question of which new areas of scientific exchange currently hold promise for U.S.-Soviet cooperation. The workshop itself represented a somewhat different breakdown of disciplines than the categories included under the previous agreement. Most notably, astrophysics and heliospheric studies were broken out as separate disciplinary groups. One promising new area is the field of "global habitability," which includes a wide range of integrated earth environmental observations. The vast size of the Soviet Union makes that country's participation in this field especially important.

In the life sciences area, the field of exobiology (i.e., non-terrestrial biology and biochemistry) offers some interesting new possibilities for future cooperation. Studies in this area might include search for extraterrestrial intelligence (SETI), or joint collection and analysis of Antarctic meteorites. Global biology would be an important aspect of the global habitability studies just described. Another new cooperative area might be the joint demonstration and testing of advanced life support systems, including those of the "closed," or bioregenerative, type.

In solar-terrestrial physics, comparison of American and Soviet research plans indicates that mission coordination and data exchange would yield substantial scientific benefits for both countries. Integration of Soviet data into the online data processing and exchange program now being developed for the International Solar-Terrestrial Physics Program would be especially valuable, according to scientists in this field.

Astrophysics offers several promising opportunities for complementary and mutually advantageous cooperation. In the radio area, joint missions in very long baseline interfermetry (VLBI) could be undertaken using independent U.S. and Soviet spacecraft. with collaborative planning for the orbits and frequencies to be used. U.S. Spacelab experiments involving large-scale equipment such as X-ray detectors of large collecting area, could be reflown on the Salyut for long-term exposure. In the first example, two essentially free-standing missions enhance one another by proper coordination and planning; in the second, the scientific potential of expensive experiments is realized more fully by a much longer time for making observations in orbit.

Possibilities for cooperative ventures in the planetary field are numerous, including: lunar geochemical orbiters, continued lunar sample exchange, joint Venus missions (studies of the atmosphere as well as long-lived surface missions); coordination of separate Mars missions or even a joint Mars sample return mission; comet rendezvous and sample return; and outer planet exploration.

A final topic of discussion was the question of whether better cooperative results would be achieved by simply resuming the former cooperative program (with certain changes to reflect evolution in U.S. and Soviet programs since 1982), or by basing the agreement upon some future high-visibility "science spectacular" that would capture the world's imagination. Candidates for such a mission might include a joint Mars sample return or a joint "Starprobe" mission to the Sun. Clearly, a joint manned mission would be considered for such a spectacular, but workshop participants were insistent that such a mission would have little lasting significance if it did not include substantial scientific content. Although determining the ground rules for future cooperation is ultimately a policy issue, workshop participants thought that any policy decision ought to be made in the light of scientific feasibility.

The consensus was that, given the difficulties inherent in large-scale joint missions, it would be wise to begin with simpler exchanges of the type still continuing and to hold out the possibility of such a mission as a long-term goal.

SUMMARY

Past interactions with the Soviet Union in the context of space science have significantly benefited U.S. scientific programs. Based on perceptions of current Soviet attitudes and behavior, there is ample reason to believe that such interactions would again be fruitful, given an appropriate official framework. In recent years Soviet scientific capabilities as well as mission opportunities for conducting space research have risen sharply, so that, indeed, the U.S.S.R. now offers more in the way of potential cooperative exchange than in the past. At the same time, Soviet scientists have apparently become more willing to share data and plans. The increased Soviet strength in space science also means that oft-expressed U.S. fears of damaging technology transfer may now be less warranted than they were in the past. On the contrary, technology transfer into the United States could become a factor in some areas of space science, such as planetary landers and plasma physics. Nevertheless, the issue of technology transfer is still problematical for the United States, and will continue to receive serious attention in the OTA study.

As a result of new Soviet capabilities, there is now greater opportunity than in the past for a substantive, broad-based exchange that is equally balanced on both sides. In addition to the renewal of previous areas of scientific exchange, any future cooperative agreement could include provision for new areas of joint work (e.g., astrophysics and global studies) that take advantage of our respective strengths and meet mutual needs. A dramatic joint mission to Mars or the Sun could be considered as a long-term goal, to be reached through successive cooperative steps. In any such agreement, an open approach toward the types and mechanisms of cooperation might well be taken; any forms that seem feasible and useful in a particular case ought to be considered. For example, joint coordination of separate missions is an effective way to maximize scientific return while minimizing problems of technology transfer and mission management.

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One relatively new feature of the Soviet space science program holds potentially serious implications for the United States. As Soviet capabilities have increased, the Soviet Union has opened up its space program to a considerable extent, and has demonstrated a willingness to undertake ambitious cooperative projects for scientific as well as political advantage — even taking a lead role in some planned and ongoing multinational ventures. Cooperation in space activities is becoming a competitive tool which the Soviets seem prepared to wield vigorously. If the trend toward internationalization of space activity continues, then the U.S. may have to decide whether to compete or to cooperate with the Soviet Union — or else face the prospect of losing the manifold benefits of space cooperation with our traditional partners. This is not to suggest, of course, that cooperation should be viewed as a substitute for independent space capabilities. A key point of the workshop was that the U.S. must have a strong, active space program of its own in order to be viable as a cooperative partner — whether with the Soviet Union or others. But such cooperation can, in turn, greatly enhance U.S. knowledge and capabilities.

POTENTIAL U.S./U.S.S.R. COLLABORATIVE ACTIVITIES

Sun-Earth (Heliospheric)

- Joint meetings to develop space plasma theory
- Joint coordination and data exchange in solar terrestrial physics — specifically for International Solar-Terrestrial Program (US/ESA/Japan)
- Exchange of co-investigators
- Hosted instruments (detectors)
- Joint Starprobe mission to the Sun (very long range)

Astrophysics

- Joint planning for:
  - Gamma-ray burst studies using Gamma Ray Observatory and other spacecraft
  - very long baseline interferometry (complementary orbits of spacecraft)
- Data exchange regarding contamination of cooled surfaces (IR telescopes) and plasma glow problems (UV telescopes)
- Co-investigators on Space Telescope, Gamma Ray Observatory, and Advanced Astronomical X-ray Facility
- Mounting of Spacelab experiments on Salyut for long-term exposure

Planetary

Venus

- Joint planning or joint missions as part of a sequence to investigate the properties of the atmosphere of Venus
- Joint planning/missions for "long-lived" Venus surface studies

Mars

- Coordinated planning for Mars missions ca. 1990 (Phobos lander and Mars Geochemical Climatological Orbiter (MGC0))
- Joint planning/missions for Mars sample analysis or return

Moon

- Lunar geochemical orbiters
- Continued lunar sample exchange

Comets

- Soviet contribution to instrument design for U.S. mission to Comet Kopf (1990) [possibly a hosted experiment]
- Coordinated or joint cometary sample return missions

Outer Planets

- Joint orbiter/probe missions to Saturn, Uranus, or Neptune [after the NASA/ESA Cassini mission to Saturn and Titan, Uranus is the next cooperative opportunity here]

Life Sciences

Effects of Long-Duration Spaceflight

- Data exchange and joint or hosted flight experiments, especially on problems of (human) bone loss, radiation effects, life support, and countermeasures
- Joint ground-based simulations (e.g., long-duration bed rest)
- Joint (or hosted) biological experiments aboard Cosmos biosatellites and/or Spacelab, using various animal and plant species

Exobiology

- Joint unmanned missions or data exchange to further investigate the question of life on Mars
- Joint meetings and/or data exchange regarding search for extraterrestrial intelligence (SETI)
- Joint collection and analysis of Antarctic meteorites

Global Biology

- Earth observations data exchange

Life Support Systems

- Joint ground-based demonstration and flight testing of life support systems (including bioregenerative type)

Senator MATHIAS. Once again, we thank you for being with us. The committee will stand in recess subject to the call of the Chair.

[Additional questions and answers follow:]

STATE DEPARTMENT'S RESPONSES TO ADDITIONAL QUESTIONS SUBMITTED FOR THE RECORD

Question 1. Which United States-Soviet cooperation agreements are in effect today and which were allowed to lapse?

Answer. Reflecting changes in the overall political situation in the wake of Soviet invasion of Afghanistan in 1979 and the imposition of martial law in Poland in 1981, the level of cooperative science and technology activity under the seven active agreements has declined to roughly 20 percent of the 1979 level, when all of the original 11 agreements—environmental protection, public health and medicine, agriculture, atomic energy, artificial heart research and development, housing, science and technology, space, world oceans research, transportation, and energy—were in force. Three agreements—science and technology, space, and energy were allowed to lapse in 1982. A fourth—the transportation agreement—was ended by the 1983 shootdown of the Korean airliner. But activities of particular benefit to the United States, especially in the areas of health, environmental protection and safety, have continued since then. Moreover, the structure of scientific cooperation has been maintained intact in most areas so that beneficial exchanges can be expanded if warranted by the political situation. Consistent with this view, the United States has since 1979 renewed specialized agreements on cooperation in medicine and public health, artificial heart research and development, environmental protection, oceans, agriculture, atomic energy, and housing. We are currently reviewing the oceans agreements again for possible extension at the end of this year.

Question 2. What led the Administration to allow United States-Soviet cooperation agreements to lapse?

Answer. Three agreements (Energy, Science and Technology, and Space) were allowed to expire by the United States as part of the sanctions imposed on the U.S.S.R. in December 1981 for its role in encouraging suppression of the free trade union movement in Poland. The primary criterion in the selection of these agreements was their dates of expiration, which in all cases were mid-1982. The Administration's concern about possible technology loss through these cooperative agreements was, of course, in the background of this decision, but it was not a controlling factor. The shooting down of the Korean Airlines Flight 007 in September 1983 led the United States to end negotiations for extension of the Transportation Agreement which, in effect, terminated the agreement.

Question 3. Please summarize the benefits the United States has accrued through these agreements? What risks does the United States run from United States-Soviet cooperation, in general?

Answer. Part 1 of question 3 (Summary of benefits to United States):

The contacts between the science establishments in the United States and U.S.S.R. have, in an overall sense, provided us with a better understanding of the capabilities of Soviet science, an opportunity to conduct joint research in areas where the Soviets are more advanced and/or have unique resources data, or facilities, and direct communication of American views to an influential strata of modern Soviet society. Particular areas of science and technology where United States exports have profited from these contacts are, among others, high-energy physics, advanced electroslag remelt techniques, laser treatment of glaucoma, studies of long-range air pollution, light-weight concrete contruction technology, and effects of long-duration manned spaceflight missions.

Part 2 of question 3 (Risk for United States in cooperation with the U.S.S.R.):

Answer. In general, the United States risks building up expectations of political and/or scientific benefits that may not prove out. In addition, there is a potential for the transfer of technology in some areas that could affect U.S. national security interests. For these and other reasons, the key to proper scientific and technical relations with the U.S.S.R. is, as in other areas of the relationship, reciprocity and careful structuring. Cooperative programs must be designed for validity on their scientific merits, not to suit transient political moods. They must be carefully reviewed to minimize the risk of undesired transfer of techology. The contributions each side is to make to a program must be carefully evaluated and kept in balance. The work must be carefully monitored to ensure that each side is keeping its commitments scrupulously. American project managers must communicate frankly with political levels, so that all concerned are aware of what is actually occurring in cooperative projects. Moveover, cooperative programs should be arranged only when the Soviets

bring to them a unique or important capability. We should enter into cooperative projects that promise to bring from United States-Soviet interaction a scientific result or benefit that otherwise would be unlikely to be achieved or would be long delayed without that interaction.

Question 4. Space technology is perhaps the most advanced aspect of American know-how. Is the Administration particularly concerned about technology transfer to the Soviet Union? Is this the key motive for Administration reservations in this area of cooperation?

Answer. The concern felt about possible space technology loss to the Soviet Union through cooperative projects is significant, but it is not the controlling factor in our overall approach to space cooperation with the Soviet Union.

Question 5. In June, the President expressed his desire to renew several United States-Soviet agreements for cooperation and proposed a joint space rescue exercise.

(a) Does this indicate the Administration intends to seek renewal of the United States-U.S.S.R. space cooperation agreement?

(b) If not, do you believe we can initiate this activity, given the importance the Soviets attach to formal cooperation agreements?

(c) Are there other areas of space cooperation you intend to pursue in the near future? If so, which?

Answer. (a) The Department believes that it would be premature, at the current time, to address the possibility of a new overall space agreement between our two governments, given the Soviet attitude to date toward the simulated space rescue proposal.

(b) The U.S. proposal for a simulated space rescue mission could entail a formal arrangement to underpin that project; such details would have to be ironed-out with the Soviet Union.

(c) We are taking a step by step approach. We believe that we have a very sound, and mutually beneficial, proposal on a space rescue mission before the Soviet Union for its consideration and we remain hopeful that they will eventually see the merit in that proposal. If the Soviets decide to join with us, new avenues could very well open over time.

Question 6. What actions have been taken to pursue the President's initiative?

Answer. The United States proposal for a simulated space rescue mission has been pursued through diplomatic channels.

Question 7. How have the Soviets reacted to our proposals on cooperation?

Answer. With respect to our proposal for the simulated space rescue mission, the Soviets have chosen not to address the substance of the proposal, but have made clear they do not consider substantive discussion appropriate for the time being at least.

Question 8. The Soviet Union has rejected a return to arms control negotiations. Are prospects any better for increased ties with Moscow on economic, scientific and cultural cooperation? Please explain your assessment.

Answer. In his speech June 27, 1984, before the participants of the Smithsonian Institution symposium on United States-Soviet exchanges, President Reagan clearly stated his desire to improve the United States-U.S.S.R. working relationship and listed some sixteen areas where we were undertaking steps in this direction. Among his examples were the Administration's proposal to strengthen cooperation under our bilateral agreements in environmental protection, housing, and health; our proposal (which the Soviets accepted) to extend for another 10 years the United States-U.S.S.R. Long-term Economic, Industrial, and Technical Cooperation Agreement; and our desire to enter into a new General Agreement on Exchanges, Contacts, and Cooperation (the so-called Cultural Agreement). Negotiations for the Exchanges Agreement are now underway and substantive steps have been taken on the other examples.

NASA's Responses to Additional Questions Submitted by Senator Mathias

Question 1. Space technology is perhaps the most advanced aspect of American know-how. Is the Administration particularly concerned about technology transfer to the Soviet Union? Is this the key motive for Administration reservations in this area of cooperation?

Answer. The Administration is seriously concerned about technology transfer in the space area to the Soviet Union. We believe, however, that with proper attention the problem can be managed. It is with this in mind that this Administration made the proposal to the Soviet Union for a simulated rescue mission.

Question 2. Mr. Morrison, what is NASA's assessment of the Soyuz-Apollo cooperative venture? Did the United States gain as much as it contributed?

Answer. NASA's assessment of the Apollo-Soyuz is that the mission was a success. Little or no technology was transferred to the Soviets although it is believed that they did learn a considerable amount from us about management techniques. It is our feeling that the United States on balance did gain as much as was contributed.

Question 3. Mr. Morrison, do you know of areas in space science and technology where the Soviets hold a lead and where we might profit from collaborating with them? If you can, please name a few?

Answer. In manned space flight, the Soviets have focused on the progressive extension of mission duration onboard their Salyut space stations, and the cosmonaut crew currently in orbit is establishing a new world record beyond the 211-day record they previously established. The U.S. manned program, on the other hand, has emphasized development of the Space Shuttle, which currently has a maximum in-orbit staytime capability of 7 to 10 days. In view of our complementary programs, regular, open exchanges of biomedical data with the Soviets would contribute to our overall understanding of the effects of weightlessness on humans, and in particular, as NASA proceeds to develop the Space Station, knowledge of the Soviet experience would be extremely useful in assessing the optimal space flight duration for rotating crews.

In space biology, the Soviets have launched a series of unmanned biological satellites since the early days of their space program to the present. The United States has not flown dedicated unmanned biosatellite missions since the early 1970's and there are no plans to do so in the forseeable future. Cooperation with the Soviets in this area offers flight opportunities for U.S. investigators and allows us to regularly conduct biological experiments in space that would otherwise be difficult to do solely via manned Shuttle/Spacelab missions.

In the planetary area, the Soviets have missions planned for Venus, Comet Halley, and Mars. The United States stands to gain significantly through exchanges of data and scientists, and the knowledge of Soviet future plans and missions obtained through official channels would aid us in planning our own future missions as well as provide an opportunity to analyze data from projects currently under development.

[Whereupon, at 12:33 p.m., the committee adjourned, subject to call of the Chair.]

APPENDIX

STATEMENT OF THOMAS M. DONAHUE, CHAIRMAN, SPACE SCIENCE BOARD, NATIONAL RESEARCH COUNCIL

U.S. SOVIET COOPERATION IN SPACE EXPLORATION

Thank you for inviting me to comment on cooperative East-West ventures in space. As you know, I am Chairman of the Space Science Board of the National Research Council, a Board that is charged with the responsibility of advising the various elements of our government concerning space science issues. Our competence is scientific and so I shall confine my remarks here to areas having to do with the scientific benefits that I see as accruing from cooperative ventures in space between East and West.

I have little doubt that a very great increase in the productivity of the world's efforts in space sciences research could result from a fully developed international cooperative program, an increase that would result in a considerably greater return to each participant per unit invested in its space science program. Let me try to explain why I think this is so.

First of all it should be understood that there are competent programs in space research underway at several places in the world other than the United States. Individual nations in Western Europe such as France and the Federal Republic of Germany have their own science programs with access to space via the European launcher. In addition many of them, including the two mentioned, are banded together into a joint program operated by the European Space Agency (ESA). That agency is developing a mission to Comet Halley for launch next year and an ambitious Infrared Astronomical Space Observatory. It has recently generated a plan for an exciting series of space science missions to be started between now and the year 2004. In the Far East Japan has its own independent and vigorous space science program. It, too, is among the nations planning to launch spacecraft to meet Halley's Comet when it arrives in the inner solar system in 1986. And of course there is the U.S.S.R. with its very active space science program, one that has a very great advantage now over our own in that they are launching missions at a steady pace while we have been in a position of marking time. In a systematic way the U.S.S.R. has been sending spacecraft at virtually every opportunity to land on the surface of Venus and analyze conditions there—a really technological success given the fact that the temperature there is 900°F and the pressure 90 times as great as it is on the surface of the Earth. They now have two spacecraft orbiting that cloud shrouded planet making radar maps of its surface. They are about to launch two spacecraft that will drop off packages at Venus and continue on to encounter Halley. They plan to return to Venus again and again, to fly on to rendezvous with asteroids, and to put spacecraft in orbit around Mars that will keep station with Phobos, one of the two moons of Mars. They have plans for missions to continue their studies of the Earth's magnetosphere and also intend to orbit spacecraft around the Earth that will be elements in a Very Long Baseline Interferometry system for radio astronomy. I recite this list to make a point. The technological and scientific expertise to do space science is not monopolized by the United States, far from it. In considering cooperative ventures in space science we are contemplating cooperation among partners who have achieved essential parity in the level of their ability to carry out advanced programs in space research.

Furthermore, many of these nations and organizations are already engaged with each other in joint enterprises of planning for joint missions in the future. The nations of Western Europe have a long history of mutual enterprises with the United States. Recently, the Space Science Board and the European Science Foundation laid the groundwork for joint NASA-ESA missions in planetary science that even contemplates cooperation in obtaining and returning samples from the surface of Mars. The U.S.S.R. in recent years has been energetically promoting the participa-

tion of scientists in Eastern bloc countries in its science program through the Intercosmos organization. The French and others in Western Europe are very active in cooperative scientific space studies with the U.S.S.R. and Intercosmos. And ESA and the U.S.S.R. are exploring the possibility of cooperation in future space missions. I was pleased to be invited by Dr. R. M. Bonnet, the Director of the Scientific Program for ESA and Academician R. Sagdeev, Director of the Soviet Institute for Cosmic Investigations to participate in an ESA-Intercosmos planning meeting this summer in Vienna and can testify to the lively and frank way in which those present discussed future common ventures.

Obviously, formal joint programs involving the two nations with the biggest space programs, the United States and the U.S.S.R., are not among those I have listed. From a scientific point of view that is regrettable. The reason is that there are many ways in which adding together the resources for space science of these two nations would greatly enhance the scientific returns from the human investment in space science. This kind of science is very expensive. There are many enterprises well worth undertaking that would sorely tax the resources of the United States, the U.S.S.R. or ESA to undertake separately—such as a mission to return samples from Mars or Venus. Sharing the responsibility for such missions—that involves a number of quasi independent operations and are readily separable into two or three parts—might enable us to undertake these scientifically urgent enterprises that otherwise may be beyond our individual grasp for a long time to come.

I can think of many other scientific studies that need a multitude of space vehicles to be complete, or that would be enhanced greatly by the existence of several separate systems. A fleet of spacecraft consisting of perhaps as many as six is needed to investigate adequately the interaction between the solar wind, the magnetosphere, the ionosphere and the upper atmosphere of the Earth. This solar-terrestrial program is a natural one for cooperation among the space agencies of the United States, Europe, the U.S.S.R. and Japan. The United States, ESA and the U.S.S.R. all are interested in placing radio astronomy receivers in orbit in order to deploy a system called a very long baseline interferometer. One carefully orchestrated set of two or three such receivers in orbit simultaneously is far more powerful than two or three operating independently and at different times. The United States and the Soviet Union both have plans to send orbiters to Mars. Although the missions have different purposes, their payloads could be designed so that they would be mutually supportive if plans were laid to have them present near Mars at the same time and operating in concert. Earth scientists on the Space Science Board are developing proposals for an intensive study of the Earth as a planet—plans that involve networks of surface sensors and lower atmospheric sounders as well as remote sensing devices in orbit. A study of the entire Earth would be handicapped if all parts of the planet should not be involved in the study. I could go on with many more examples, but I hope that these are sufficient to make the case for the scientific value of cooperation.

There are other levels of cooperation, less exalted than the ones I have discussed, that also can produce valuable returns. Joint discussion of results obtained on separately conducted missions still goes on and is indispensable. This kind of discussion can and does influence the design of new missions about to be undertaken. For example, the Soviet scientists have come forward quickly with radar maps of Venus obtained by their current Venera 15 and 16 missions and shared these maps with their Western colleagues. Consequently, the design of the U.S. Venue Radar Mapper mission, now in preparation, will be altered so as to improve its resolving power and allow it to distinguish surface features about 400 feet in span—about one tenth the size of those the U.S.S.R. instruments can distinguish. The usefulness of such an improvement was clear from the study of the Soviet results. Had the Soviet scientists guarded their data until the time of its formal publication, modification of the U.S. apparatus would have been very difficult and very much more costly than it is now, if not entirely impractical and progress in science would have been the loser.

Scientifically, it is very dangerous and unsound to leave some large areas of investigation to one set of scientists. Independent verification of the results of experiments, observations or calculations is a necessary indispensable part of the scientific enterprise. Thus, experiments on the surface of Venus ought not to be left to the U.S.S.R. or Intercosmos alone, and studies of Titan should not be reserved to a small set of U.S. scientists. But the means to get instruments to Venus or Titan are costly. Duplicating these makes little sense. Making vehicles available to carry instruments provided by scientists from all of the nations of the world makes scientific sense. This is another potential mode of cooperation that would be very productive.

For all of these reasons, implicitly or explicitly exprees, I can assert with confidence the value to science of cooperative East-West ventures in space.

STATEMENT OF EDWARD F. SNYDER, FRIENDS COMMITTEE ON NATIONAL LEGISLATION, WASHINGTON, DC.

My name is Edward F. Snyder, Executive Secretary of the Friends Committee on National Legislation. We support the prompt passage of S.J. Res. 236. This bill urges the President to renew the United States-Soviet space cooperation agreement which existed between 1972 and 1982 and to initiate talks with the Soviet Union and other governments on cooperative East-West ventures in space as an alternative to the arms race in space. While we do not claim to speak for every individual Friend, we think there would be overwhelming consensus among Friends in support of this proposal.

We commend Senators Matsunaga, Mathias, Pell and the 11 other cosponsors of S.J. Res. 236 for their leadership on this issue, as well as Representative Mel Levine and the 74 cosponsors who introduced a similar resolution in the House.

In our view, this and similar proposals for joint United States-Soviet communication, exchanges and projects will do more to increase U.S. national security than all the missiles and bombs Congress will add to the overcrowded U.S. arsenal this year.

Joint United States-Soviet projects increase U.S. security by creating an atmosphere in which irrational fears are diminished, more realistic assessments of motives become possible and the danger of nuclear war is lessened. By establishing patterns of cooperation and by demonstrating that these nations do indeed share certain common goals, joint projects help on both sides to "humanize the enemy." They help create a climate in which the initiation of a nuclear war, or the threat to use nuclear weapons, becomes an unthinkable policy option for the leaders of either the United States or Soviet Union.

At the present time, the United States is contemplating an incredibly expensive, complex, long-term, and--many say—impossible effort to prevent enemy missiles, once launched, from reaching the United States.

What we need instead is a crash program to prevent these missiles from being launched in the first place. S.J. Res. 236 is a creative first step in such a preventive policy, at much less expense than the proposed space defense initiative. In addition, it offers the possibility of many additional benefits in the fields of medicine, space science, communication, weather forecasting, identification of resources, verification, rescue and space exploration.

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